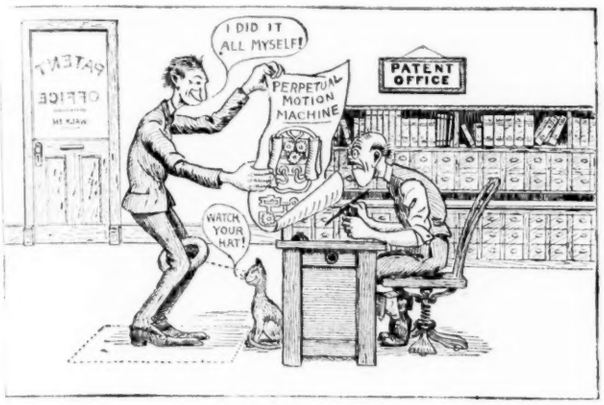
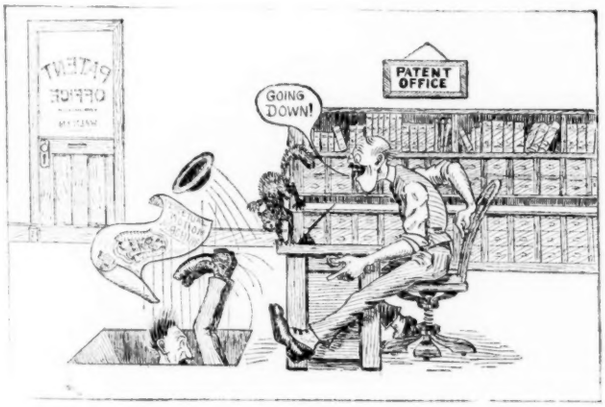
POWER

Volume 48 New York, November 19, 1918 *Number* 21

Use Him Rough!



If I'd a job with Uncle Sam at Washington, D. C.,
And applicants for patent rights were forced to come to me,
I'd treat them all with courtesy and give them close attention,
For I've respect for any man who makes a great invention;
But no perpetual-motion bug would claim my time for long,
Because to waste the public's time on such is wholly wrong.
I'd have a trapdoor in the floor, and when he stepped upon it,
I'd press a button and he'd drop from underneath his bonnet.



I'd have to use him rough, I fear, for there's no better way,
You couldn't talk sense into him, not if you tried all day;
And time these days is precious stuff and much too scarce to fritter
On anyone so imbecile as this aforesaid critter;
And as he went down through the trap, I figure the sensation
Of falling might recall to him the law of gravitation,
And though for friction he had never seemed to care a hoot,
He'd feel it on his trousers' seat while shooting down the chute.

As he emerged at length into the corridor below,
He'd see a poster on the wall, designed to let him know
That Uncle Sam is waging war against a foe of might,
And that his nephews everywhere must either work or fight.
A lettered sign would show him where we'd help him find a job,
Another, where he could enlist to fight the Hunnish mob;
The latter one might stir his soul to take some interest in
The grand perpetual motion of our army toward Berlin!

Verses by Louis P. Allen

Home-Made Water-Softening Plant

By H. D. ODELL

Boiler-feed water was of such character that treatment was necessary. A home-made softening system was installed. At first the results were unsatisfactory, owing to improper use of chemicals. A chemist was employed to formulate a proper control, which gave satisfactory results.

TROUBLE with the boiler-feed water was responsible for the installation of a home-made water-softening plant, the system used being a lime-soda process, treating in the cold. The well from which water is obtained is about one-quarter of a mile from the Colorado River and is sunk in a fine gravel bed, which forms a natural filter. The well is 10 ft. diameter, 30 ft. deep and is curbed with concrete rings. It has a natural flow of water from the river which gives a water level of from 9 to 12 ft. when pumping.

For about a year the water from this well was satisfactory. Not that it would not scale the boiler, but it was as good as the average water, and it would not cause one to seriously consider the installation of a softening system. During this first year we cleaned our water-tube boilers every three months by pushing a scraper through the tube and by scraping the drums; and usually once a year a steam-turbine cleaner was run through them to be certain that they were clean. Although this method of cleaning kept two men busy, they were never rushed and kept the boilers in good condition.

About two miles to the west and north of the power plant on the Colorado River a dam 65 ft. high was in course of construction at the time our well was sunk, and water had been used from the well about a year when the dam builders reached a point that enabled them to close all the sluice gates and let a lake form above the dam; this lake extends about twenty miles when the water is high enough at the dam to overflow.

Our trouble began shortly after this lake was formed, and at first we were at a loss to understand the change in the water. The fuel consumption increased, tubes would blister, bag and rupture, and they wasted away where they were rolled in the risers or headers. It seemed that each day conditions became a little worse than the day before.

We decided that our trouble was caused by the water from the lake finding its way through the hills above the plant, which are mostly limestone, and entering our well. Investigations proved this to be so, as it was discovered that two large veins had opened up under the north edge of the well curbing.

The water was so bad by this time that we had to clean each boiler every fifteen days, using a turbine cleaner. If this was neglected, we were sure to lose some tubes. It now kept four men and two turbine cleaners on the jump all the time to keep things going.

We tried treating the water with different compounds, which only made settling tanks of the boilers and kept us blowing heat units into the sewer, and in some cases caused excessive priming. Boiler graphite was the only thing that helped; it made the boiler easier to clean, but did not prevent the scale from forming on the metal. It seemed to keep the scale soft, however, and that was a help.

It was realized that the time had come to do something to remove the solids from the water or abandon the well, and this we did not want to do—first, on account of the money already invested, and second, because it was too expensive to use city water, and conditions were such as to prevent us going to the river for water. So we decided on a softening system to purify the feed water before it went to the boilers.

A spray system is used for cooling the circulating water for condensing purposes. The concrete cooling basin is 42 ft. wide by 120 ft. long and is 4 ft. deep. The water from this basin flows by gravity through a 12-in. pipe to a sump in the power house from which all pumps are supplied. As 15 lb. pressure is carried on the discharge line to the sprays, this line is connected to the heater for boiler water. It was decided to locate the softening tanks at one end of this cooling basin (Fig. 1) which would facilitate its operation.

An engineer who was credited with being a good chemist, was employed to work out the problem and decide on the proper water treatment. The system, when

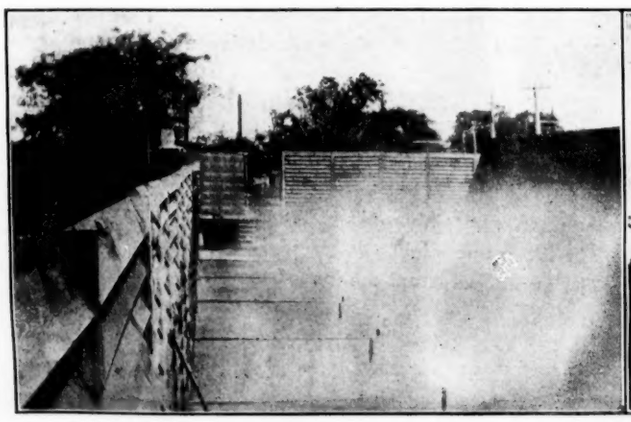


FIG. 1. COOLING POND AND WATER-SOFTENING TANKS

FIG. 2. WATER-SOFTENING TANKS ON PLATFORM

completed, consisted of two wooden tanks each of 10,000-gal. capacity, located on a platform that was elevated the proper height above the cooling basin for emptying (Fig. 2). Above the treating tanks is a second platform, large enough to accommodate two 52-gal. chemical barrels and standing room for one man; one barrel is for soda ash and one for lime. A stairway between the treating tanks leads up to this platform. Adjoining the treating plant is a room 15 x 18 ft. that is used for storing soda ash and lime and a set of scales for weighing each dose.

Various articles have been published asserting that an engineer does not have to be a chemist in order to operate a softening system. This is true only if some chemist has made a control by which the inexperienced person can guide his actions in treating the water. But there are several reasons why one should not "go it blind" in treating water with soda ash and lime. Overtreating with soda ash will cause excessive priming; undertreating will cause the solids to leave the water after entering the boiler in a state of sludge, and although it does not seem to harden or bake on the metal, once it settles, blowing down will hardly ever dislodge it. Then it increases in size and thickness until a blister or a rupture results. My advice to anyone contemplating a softening system is to employ a competent chemist at the start and keep him until the operator thoroughly understands his work, as time and money will be saved.

Scale-Forming Solids in Water Should Be Known

Although the main control of a softening plant is the continual testing of the treated water, one must have a starting point by knowing the kind and amount of scale-forming solids the water contains. This the consulting engineer did not give us. By all means have a competent chemist come on the job and test the raw and treated water for a while in order to note the changes in it; from this data he can formulate a control table that any handy man about the plant can understand and so operate the softening plant satisfactorily.

Using the instructions left us, we operated our softening plant for several months with the conditions greatly improved, but the results were not what had been expected, because the treatment was mostly guesswork and partly because the treated water did not settle quickly enough to supply the demands and raw water had to be pumped into the cooling basin each day. The slowness of the treated water in settling was due to the method of agitating during treatment. Originally the raw-water pipe to the tanks was led up through the bottom center of the tank and this pipe was fitted with a cross-connection about 12 in. above the tank bottom. Branching horizontally from the cross, four curved pipes were led to within 12 in. of the tank sides; as water was pumped through these curved pipes, it gave the water in the tank a circular motion, and by the time the tank was full the motion was rather swift. But it was the wrong kind of agitation, for the water turned as a solid mass, while it should have been broken up to be thoroughly mixed.

As there was a small motor-driven air compressor at the power plant, it was decided to abandon the former method of agitating and try air. A ½-in. pipe was led from the compressor to the tanks, entering over the top and center of each, and extending to within 3 ft. of the bottom and reducing to a ¼-in. pipe, branching horizontally in four directions to within 12 in. of the tank walls. Holes $\frac{1}{16}$ in. diameter were drilled through the pipe and spaced 12 in. apart on each ¼-in. pipe. When the pipes were screwed tightly into fittings, these holes were on the side. With 25 lb. air pressure at the tanks, the effect was satisfactory. With the old method of stirring it took each tank 20 hours to settle; using air, the water would clear in four hours.

Another discouraging element in the softening process was that the boilers primed excessively, which made it necessary to blow down too often for economy, and although there was a separation in the steam mains, a white limey substance would carry over with the steam and cause the primary relay-valve stems on the turbines to stick, which was annoying. Of course this trouble arose from excessive treatment with soda ash,

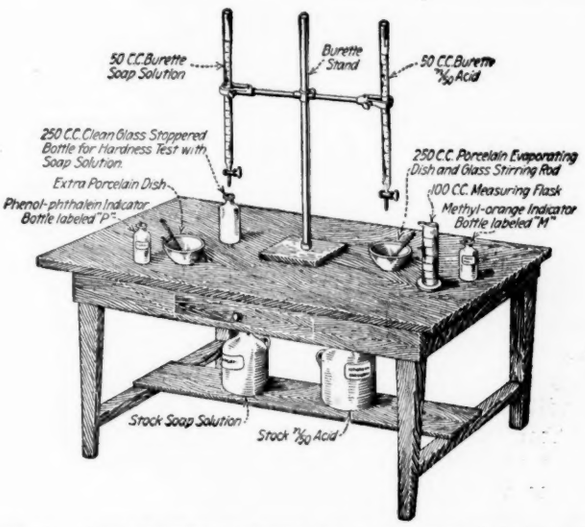

50 C.C. Burette Soap Solution
Burette Stand
50 C.C. Burette 7/50 Acid
250 C.C. Clean Glass Stoppered Bottle for Hardness Test with Soap Solution
Extra Porcelain Dish
Phenol-phthalein Indicator Bottle labeled "P"
250 C.C. Porcelain Evaporating Dish and Glass Stirring Rod
100 C.C. Measuring Flask
Methyl-orange Indicator Bottle labeled "M"
Stock Soap Solution
Stock 7/50 Acid

FIG. 3. APPARATUS NECESSARY FOR TESTING WATER

causing an abnormally high concentration of alkali salts, which would lead to foaming even though there were no suspended solids in the water.

At this point the services of a real chemist were secured, and he tested and treated the water for some time. His investigations proved that we were overtreating with soda ash and undertreating with lime. He worked out a control that should be of interest. A number of tests were run on tanks of water, using slightly varying amounts of lime and soda. The raw and treated water was tested, as will be described.

The apparatus necessary for making tests of raw and treated water can be obtained of any dealer in chemical supplies and consists of the following: Two 50-c.c. (cubic centimeter) burettes with glass stopcocks, $\frac{1}{10}$ c.c. divisions; two porcelain evaporating dishes, shallow form 6 in. diameter, inside glaze; two dropping bottles, preferably with glass stopper and grooved pouring point on stopper; one measuring flask of 100-c.c. capacity, one 250-c.c. glass-stoppered bottle for hardness test with soap solution; six glass stirring rods, about ¼ in. diameter, with rounded ends: Six glass bottles, 1-gal. capacity fitted with cocks; one burette stand for holding two burettes; two 3-in. glass funnels. An idea of the

apparatus in place ready to use is shown in Fig. 3. To test for alkalinity measure out 50c.c. of raw water (the alkalinity of raw water will be designated by M) in the 100-c.c. measuring flask and pour into the 6-in. porcelain evaporating dish. Then add three drops of methyl-orange solution, which will change the color of the water to yellow; place the dish under the cock of the 50-c.c. burette holding fiftieth normal ($^n/50$) acid to titrate. Have a scratch pad and pencil handy, and from the 50-c.c burette holding the $^n/50$ acid read the figures that indicate the height of $^n/50$ acid (hydrochloric) in the burette. For example, assume that these figures are 6.8, put it down on the scratch pad as $M = 6.8$. Then open the cock on this burette and allow the $^n/50$ acid to drop slowly into the evaporating dish holding the raw water and stir with the glass rod until the color changes from yellow to orange and finally to faint pink, at which close the cock and stop stirring and again read on the burette the figures that indicate the height of the acid. This time the figures are, say, 20.8; put it down thus: $M = \frac{20.8 - 6.8}{14}$, which indicates that 20.8 — 6.8 = 14. Next compare this 14 c.c. with the table shown herewith and use the relative amounts of soda ash and lime indicated, which shows that to each 10,000 gal. of water 36 lb. of lime and 26 lb. of soda ash must be used.

Cubic Centimeters $^n/50$ Acid	Lime Required per 10,000 Gal. Water	Soda Ash Required Per 10,000 Gal. Water
10	26	18
11	28	21
12	31	23
13	34	24
14	36	26
15	38	28
16	41	29
17	44	31
18	46	33
19	49	36
20	51	37

Soda ash and lime should now be put in their respective barrels (which are located above the settling or treating tanks) and thoroughly dissolved in water. Enough lime and soda ash for a 10,000-gal. run is put in the barrels at one time and this should be done when tank No. 1 begins to fill, so that it will be dissolved and ready to run in when the tank is within one to two feet of being full. It is easier to dissolve the chemicals if a ¼-in. steam line is led into each barrel. The entering steam will heat and agitate the water at the same time, which makes it easier on the operator, as otherwise he would have to stir the chemicals continually to keep them in suspension. After running in the chemicals, stir the contents of the tank with air for at least an hour. Then cut off the air, let the water settle three hours, and then take a one-gallon sample and test it.

Tests on treated water will be designated as H, P and M, representing hardness, causticity and alkalinity, respectively.

In testing for causticity (P) measure 100 c.c. in the 100-c.c. measuring flask shown in Fig. 3, pour it into the 6-in. porcelain dish and add three drops of the phenolphthalein indicator, which will give the water a purple-red color. Then place the dish under the burette cock holding $^n/50$ acid to titrate. Read the figures on the burette at the acid level and put it down on the scratch pad thus (assuming these figures to be 2.5), $P = -2.5$, then open the cock and run in $^n/50$ acid, at the same time stirring, until the water has lost its color. Then read the burette, find that the acid has been run down to, say, the figures 10.4 which indicates that 10.4 — 2.5 = 7.9 and this is recorded as $P = \frac{10.4 - 2.5}{7.9}$.

To find alkalinity (M), add three drops of methyl-orange solution to the same water that has just been tested, which will give it a light-yellow color. Place the dish back under the $^n/50$ burette ready to titrate. Reading the burette, we find that our starting point now is where we left off when finding P and record it thus, $M = -10.4$.

Opening the cock, we run in $^n/50$ acid and stir until the yellow color changes to a faint red or pink, which is the color desired. Reading the burette, find, say, 15, which is recorded thus, $M = \frac{15 - 10.4}{4.6}$.

Now M does not merely amount to the acid used in this last titration, but is the sum of both P and M, which in this case is $M = 4.6$ plus $P = 7.9$ equals $M = 12.5$, and we will put it down this manner:

$$M = \frac{15 - 10.4}{4.6 + 7.9 = 12.5}$$

To treat for hardness (H), measure 100 c.c. of the treated water in the 100-c.c. measuring flask and pour into the 2.50-c.c. glass-stoppered bottle. Place the bottle under the soap-solution burette and let the solution run into the bottle about $\frac{2}{10}$ at a time, shaking the bottle hard after each addition. At first the lather will disappear instantly, but as more soap solution is added the bubbles become tougher and persist longer. Continue to add the soap solution and shake, and as long as there is any calcium ion still present, the lather will disappear. When the correct point is reached, there will be a rich lather, which will stand several minutes.

Assume that the reading of the burette at the start of this hardness test was 5.5 and at the finish is 10.4, the notation will be

$$H = \frac{10.4 - 5.5}{4.9}$$

and this is how the scratch pad will look after making a test of the raw and treated water: Raw water equals

$$M = \frac{20.8 - 6.8}{14}$$

Use 36 lb. lime and 26 lb. soda to each 10,000 gal. Treated water equals

$$P = \frac{10.4 - 2.5}{7.9}$$

$$M = \frac{15 - 10.4}{4.6 + 7.9 = 12.5}$$

$$H = \frac{10.4 - 5.5}{4.9}$$

The above values obtained for P, M and H are used as follows in diagnosing treated water:

$\frac{M}{2}$ should equal $H + 1$ up to 3. If $\frac{M}{2}$ has a greater value than $H + 3$, the water has been overtreated with soda ash, and if $\frac{M}{2}$ has a less value than $H + 1$, the water has been undertreated with soda ash:

If P has a greater value than $\frac{M}{\frac{3}{4}}$, the water is overtreated with lime, and if P has a less value than $\frac{M}{2} + 2$, the water is undertreated with lime.

Analyze the figures and see if the water is treated properly as follows:

$$P = 7.9,\ M = 12.5,\ H = 4.9$$

$\frac{M}{2} = 6.3$, which is between $H + 1(5.9)$ and $H + 3(7.9)$. Therefore the soda-ash treatment is correct.

$P = 7.9$, which is greater than $\frac{M}{2}(6.3)$ and less than $\frac{M}{\frac{3}{4}}(9.4)$. Therefore the lime treatment is correct. Now assume a case where the lime and soda treatment is not correct when:

$P = 5.3,\ M = 15.2,\ H = 7.5.$

$\frac{M}{2} = 7.6$, which is less than $H + 1(8.5)$, showing that there is not enough soda ash.

$P = 5.3$, which is less than $\frac{M}{2}(7.6)$ and shows that there is not enough lime.

It is easily seen by the foregoing that once a control is worked out by a chemist and the correct adjustments made, a knowledge of chemistry is not necessary in order to make these tests.

The standard soap solution and standard acid may be obtained in the strength desired from any dealer in chemical supplies. It will be found to be convenient to use a soap solution when 1 c.c. corresponds to 1 grain of calcium carbonate in 100,000 parts of water, where a 100-c.c. sample of treated water is taken for test. A standard acid strength equivalent to the soap solution, where phenolphthalein is used as the indicator, is fiftieth normal acid, designated as $^{n}/_{50}$.

A seven days' run of the softening plant shows the following results:

Water treated, gal.	210,000
Labor, 14 hours at 15c.	$2.10
Lime, 504 lb. at ½c.	2.52
Soda ash, 336 lb. at 3c.	10.08
	$14.70
Cost per 1000 gal. water treated	$0.07
Saving in fuel, one year's operation with treated water	$2,636.43

	Raw Water	Treated Water	
Labor on cleaning and boiler repairs	$1,961.00	$1,427.03	
Cost of boiler repair parts	400.00	.....	
Cost of chemicals	142.97	927.43	
Labor used in operating softener	.....	219.00	69.49
	$2,503.97	$2,573.46	
Net saving			$2,566.94

Although the cost of chemicals and labor for this first year's operation of softener exceeds the saving in labor and materials on boilers to the amount of $69.49, and therefore shows a saving in fuel alone, it must be remembered that for a part of this time the softener was operated with hardly any control whatever and used nearly double the necessary amount of soda ash, and it was necessary to get all the boilers in good condition again after the softener was installed, which kept us from reducing our repair force for several months. This year will show a saving in chemicals and labor.

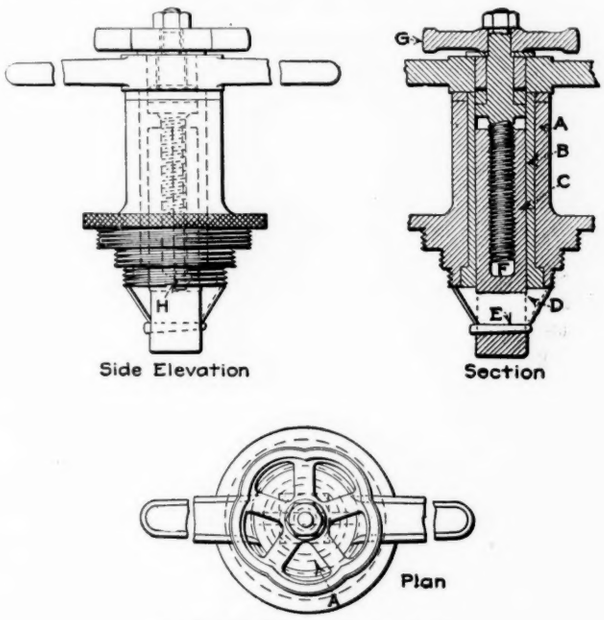
After six months' straight run, one large boiler was opened for cleaning and found to be in excellent condition. There was no scale in the drums, tubes or headers; where the feed water enters there was some loose sludge which was easily washed out. The last time this boiler was cleaned, it took four men two weeks, using turbine cleaners, and four barrows of scale was removed. This time it was cleaned in four hours by two men; as a precaution a scraper was run through each tube to be sure that they were all open and the balance of the cleaning was done with a hose.

For fear someone might be a bit skeptical as to our trouble being caused by the water from the lake finding its way around through the hills to the well, I will add that when the water from this lake was emptied about two months ago, the well water immediately became so much better that it was necessary to cut the soda-ash and lime treatment 10 and 12 lb. respectively per 10,000 gal. of water treated.

This home-made softening plant cost about $650.

Valve-Reseating Device *

A valve-reseating device which was designed to reclaim a number of old globe valves and which should be found generally useful is shown in the illustration. Its operation may be described as follows: The sleeve *B* revolves in the body *A*, and the spindle *C* slides in *B* and is splined from the cutter *D* to the upper end. The sleeve *B* has a driving key *H*, which carries the cutter. The spindle *C*, with the cutter *D*, is raised or lowered by the screw *F*, actuated by the wheel *G*. The cutter is gibbed to fit the spindle and is held in place by the key *E*. The body *A* is threaded to fit



VALVE-RESEATING DEVICE

three consecutive sizes of valves; the one shown handles 2, 1½, and 1¼ in. A separate cutter is required for each size of valve.

To use the device the valve bonnet is unscrewed and removed, and the reseater screwed into its place. The cutter is fed by the wheel *G* and revolved by the handle until a sufficient cut is made. The valve need not be removed from the pipe line.

A minor drawback to the device is that it will fit valves of only one particular brand; that is, those that have the bonnet threaded to one standard range of sizes. The cost of making the reseater is small, however, and in these days of high prices for new valves it is paid for when one valve of each size is reclaimed.

*Charles Harbottle, master mechanic, Chiksan Mining Co., Chiksan, Chosen, in the *Engineering and Mining Journal*.

Principles of Waterwheel Design

By DAVID R. SHEARER

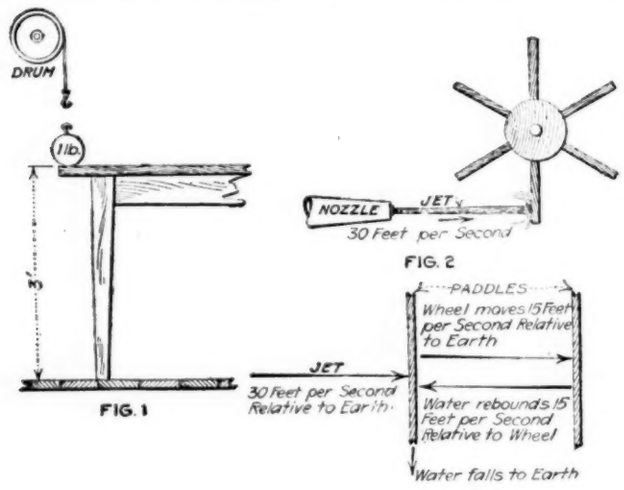
Some of the underlying principles in the design of waterwheels, referring particularly to the relation between the velocity of the water and the peripheral speed of the wheel.

TO DEVELOP a water power the energy in the water must be transferred to the rotating wheel by which work is to be done. The energy in the water may be in the form of (a) potenital energy, (b) kinetic energy, or (c) a combination of these two forms in varying proportions, depending upon conditions.

The difference between potential energy and kinetic energy may be readily made clear. Assume that an iron ball weighing 1 lb. is placed on the edge of a table 3 ft. above the floor, as in Fig. 1. When the ball is at rest, it possesses 3 ft.-lb. of potential energy relative to the floor; that is, it has energy, due to its position, equal to the product of its weight, in pounds, and its distance from the floor, in feet.

The potential energy may be increased by increasing the weight of the ball or by increasing the height of the table relative to the floor. Relative to the table, however, the ball has no potential energy whatever. To develop the potential energy into power it is feasible to attach to the ball a cord wound on a drum and allow the ball to revolve the drum and do work as it descends from the table level to the floor level.

In the same way a body of water at a higher elevation has potential energy relative to any lower level



FIGS. 1 TO 3. ILLUSTRATING ENERGY AND VELOCITY

Fig. 1—Potential and kinetic energy compared. Fig. 2—Effect of jet on stationary blade. Fig. 3—Relative velocities of jet and moving blade.

and may be caused to do work in descending, as, for instance, by turning an overshot waterwheel by its weight in the buckets on one side.

On the other hand, suppose that the ball is allowed to fall from the table to the floor. During every instant the ball is approaching the floor a part of the potential energy is being turned into kinetic energy, or energy of motion, and at the precise instant that it strikes the floor all the potential energy has been transformed into kinetic energy and no potential energy remains relative to the floor. The resulting 3 ft.-lb. of kinetic energy will be exerted in denting the floor and producing sound or heat in the board it strikes. In a similar manner a body of falling water has kinetic energy which may be developed into power by causing it to strike and turn a paddlewheel of some sort.

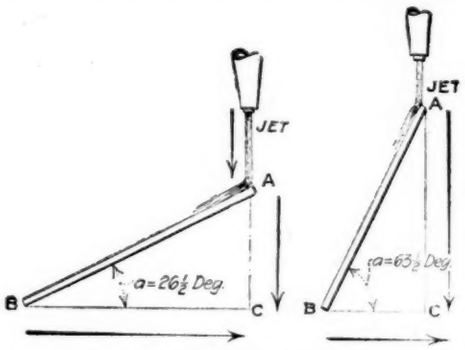


FIG. 4. DIAGRAMS SHOWING EFFECT OF ANGLE OF WHEEL BLADE

Now assume a horizontal jet of water to be flowing from a nozzle with a velocity of 30 ft. per sec., relative to the earth, as in Fig. 2. The jet has kinetic energy due to its velocity relative to the earth, and to transform all this energy into power it would be necessary to bring the jet of water to rest, relative to the earth, thus causing it to give up all its kinetic energy. Let a simple paddlewheel be placed in the jet and see what effect it will have on the rapidly moving water, and vice versa. If the paddles are kept motionless the jet will rebound with the same velocity with which it strikes, friction neglected, and will therefore give up none of its energy to the wheel. If the paddles of the wheel are revolved in the direction of the jet and at the same velocity, the water will not press against the paddles, but will pass through with unimpeded force and velocity; consequently, the wheel will absorb none of the energy.

Now, suppose the wheel is allowed to revolve with a peripheral velocity of 15 ft. per sec.; that is, the tips of the paddles move at a speed of 15 ft. per sec. The jet will then strike the paddles with a relative velocity of only 15 ft. per sec., because the paddles are already moving that fast. But the water will rebound with a velocity of 15 ft. per sec., relative to the paddles, and as the paddles are moving at that velocity relative to the earth, but in the opposite direction, the water rebounding will be motionless with respect to the earth and will simply fall to the earth without energy, as shown in Fig. 3. In this case, friction neglected, the jet of water gives up all its kinetic energy to the revolving paddlewheel, which is exactly what is desired. This type of wheel is called an impulse wheel.

From this reasoning it is found that, neglecting friction, the theoretical maximum power is secured from a wheel of the impulse type when the paddles are moving

with a peripheral velocity exactly half that of the jet relative to the earth; for when this is the case, the water jet is brought to rest by giving up all its energy to the wheel.

From a consideration of the foregoing facts it is seen that the peripheral velocity of an impulse waterwheel will depend only on the velocity of the jet, and that the revolutions per minute will depend on the velocity of the jet and the diameter of the wheel.

The velocity of a jet of water, neglecting the effect of friction, may be calculated by the formula

$$v = 60\sqrt{2gh}$$

in which

v = Velocity of jet, in feet per minute;
g = Acceleration due to gravity, or 32.16 ft. per sec.;
h = Head of water, in feet.

Assuming the value of g to be 32, as an approximation,

$$v = 60\sqrt{2 \times 32h} = 60\sqrt{64h} = 480\sqrt{h}$$

Thus, it appears that the jet velocity depends solely on the head. For a given head, therefore, the most efficient peripheral speed of the wheel is constant, since it is half the jet velocity, and so the revolutions per minute of the wheel can be changed only by varying

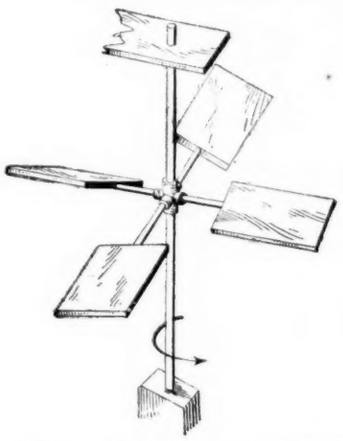


Fig. 5 WHEEL CONSISTING OF INCLINED BLADES

the diameter of the wheel. From this it follows that a 24-in. impulse wheel will run at twice the revolutions per minute of a 48-in. wheel operating under the same head.

On the other hand, it is not possible to increase the revolutions per minute of a wheel by reducing the diameter beyond a certain point without causing a great loss of efficiency. The smallest diameter of impulse wheel should be at least twelve times the diameter of the jet used on the wheel. The largest diameter is limited only by structural difficulties and low revolutions per minute.

Neglecting friction for the sake of simplicity, the following relations may now be established:

$$s = \tfrac{1}{2}(480\sqrt{h}) = 240\sqrt{h} \qquad N = \frac{240\sqrt{h}}{3.1416d} = \frac{76.4\sqrt{h}}{d}$$

s = Efficient peripheral speed of wheel, in feet per minute;
N = Revolutions per minute of wheel;
h = Head of water, in feet;
d = Diameter of wheel, in feet.

If friction is taken into account, however, the most efficient peripheral velocity of an impulse wheel will be from 0.45 to 0.49 times the velocity of the jet, and the velocity of the jet will be somewhat less than $1\sqrt{2gh}$, depending on the head and the area of the nozzle.

Turning now to the Francis reaction turbine, or mixed-flow turbine, it is found that the peripheral velocity of the wheel does not depend entirely on the head of water; nor does the number of revolutions per minute depend altogether on the head and the wheel diameter, but also on the design of the runner and buckets. This may be explained roughly by the diagrams in Fig. 4. Let AB represent the edge of a plane free to move in the direction BC, as, for instance, one of the blades on the wheel in Fig. 5. Now suppose a jet of water to strike the plane at A in the direction AC. The plane will move through the distance BC while a particle of water in the jet moves from A to C. But the relation of AC to BC will depend on the angle a. Therefore, the peripheral speed of a wheel like that shown in Fig. 5 will depend on the plane angle as well as on the velocity of the jet. Thus, in Fig. 4, if $a = 26\frac{1}{2}$ deg. approximately, BC will equal $2AC$; but if the angle $a = 63\frac{1}{2}$ deg. BC will equal $\frac{1}{2}AC$. In one case the peripheral speed of the wheel would be twice that of the jet and in the other case one-half that of the jet, provided the wheel was running light and developing no power. If these expressions are divided by two to find the speed required to develop maximum power, in one case the wheel will have a velocity equal to that of the jet and in the other case its velocity will be one-fourth that of the jet. Thus, by changing the angle of the runner buckets the speed of a reaction wheel may be varied without change in head or diameter. This is of especial advantage in the case of low-head developments, since a higher number of revolutions per minute is possible than could be secured from an impulse wheel.

The relation between the speed, head and power of a given wheel design is called the specific speed. This term may be defined as the speed in revolutions per minute at which a given design of wheel of sufficient diameter to produce one horsepower would operate under a head of one foot. It is a purely theoretical term, but serves an extremely useful purpose in making the proper selection of a wheel for a given purpose and for a particular place.

The specific speed necessary for a given site can be found by the formula,

$$S = \frac{N\sqrt{H}}{h^{1.25}}$$

in which

S = Specific speed;
N = Revolutions per minute desired;
H = Horsepower;
h = Head, in feet.

After the desired specific speed is found, it is necessary only to determine what types of wheels come nearest to the calculated specific speed. The procedure, roughly, is as follows:

The single-nozzle tangential wheel or impulse wheel is built in specific speeds of from 3 to 6, approximately, and the reaction turbine or Francis turbine, in specific speeds of from 10 to 100. The range from 6 to 10

can be secured from tangential wheels having two or more nozzles. Thus, by proper selection of type and design it is possible to get some particular wheel for practically any specific speed from 3 to 100. As an example, suppose a wheel is required to furnish 360 hp. at a speed of 900 r.p.m. under a head of 140 ft. The expression for specific speed then is $S = \frac{900\sqrt{360}}{140^{1.25}}$ = 35, approximately, which will require a reaction turbine of a type having a specific speed about that number.

Again, let it be required to develop 36 hp. at 400 r.p.m. under a head of 100 ft. Then, $S = \frac{400\sqrt{36}}{100^{1.25}}$ = 7.5, approximately, which will necessitate the use of a two-nozzle impulse or tangential wheel.

It is not possible to say that one or the other of the two types of waterwheels is the better, speaking generally, but one or the other is nearly always the better for a particular site or for specific conditions.

Again, it is hardly possible to say that any one manufacturer makes the best type of turbine, for some firms specialize on reaction wheels of high specific speed and others on low or medium types. Theoretically the proper course is to determine what kind and type of wheel is required to meet the particular conditions and then determine what manufacturer most nearly meets the type and specific speed required with stock wheels. Of course, most manufacturers will design special wheels for given conditions; but if possible a stock wheel should be used, as it will be cheaper and possibly more efficient.

Finding "Lost" Ammonia in Refrigerating Plants

By E. W. Miller

The troubleman finds a safety valve leaking considerably to the roof through a vent pipe in one plant, while in another a detached valve disk trapped ammonia in certain coils of a condenser. The causes are not found, however, without much searching and testing.

A THIRTY-TON compression plant had been installed in a large hotel. After it had been in operation for about six months, we received complaint from the owners that the plant wasted "an awful lot of ammonia." I was sent to find the cause of the trouble.

I first went around the plant with a sulphur stick in a vain attempt to locate leaks. Next the jacket water and the returns from the condenser, which was of the double-pipe type, were tested with litmus paper without revealing leaks. Next we shut off the water-cock at the bottom of each stand on the condenser, one stand at a time, and let them remain shut awhile to allow the leak, if any, to saturate the water in the coils. After a coil had been standing for about ten minutes, we opened its drain and tested the escaping water with litmus paper. There was no sign of a leak in any of the coils.

Tests of the brine cooler and the ice tank showed no leaks. Apparently the system was as tight as a drum. I then turned my attention to a number of direct expansion coils on the system, thinking that possibly some of the valves on these had been shut off on the suction end and that in these coils the liquid had accumulated. Not so.

The engineer insisted that there never was a leak worth mentioning since the plant was started and that it was seldom they had odor even from the stuffing-box. Nevertheless they had been obliged to add about 100 lb. of ammonia per week for the last six weeks!

I gave up, sat down at the desk and watched the compressor turn over. A pipe line leading from the compressor, up to the ceiling and out through the wall attracted my attention; it evidently was a vent from the safety valve. I began to smell a rat.

I slipped out of the engine room and made my way to the roof of the building. The wind was in the proper direction to blow whatever fumes might be coming from the vent pipe across the roof, and I walked right into a healthy dose of ammonia when a shift in the breeze drove it in my direction. The engineer had no doubts about where the ammonia had gone after he got up on the roof.

To overcome the trouble we had to remove the relief valve and regrind the seat. To prevent further trouble the vent to the roof was disconnected.

Detached Valve Disk Forms Trap in Condenser Coil

The ammonia began to disappear all of a sudden one day in a large cold-storage plant. It finally got so bad that they had to cut out a large portion of the plant to get enough liquid in the receiver to maintain the proper liquid seal. A thorough investigation failed to disclose anything wrong. There were two 100-lb. drums on hand, and these were put in without helping matters appreciably. Six hundred pounds more were ordered and after they were in there was only 2 in. of liquid in the receiver gage-glass. Before the trouble started they had been carrying about 6 to 8 in. in the glass.

Their troubles had just begun, however. As soon as the system was cut in again, the condenser pressure jumped from the 160 lb. generally carried to nearly 200 lb. The operators concluded that in some manner air had been drawn into the system and that this was responsible for the trouble. Of course the proper thing to do was to purge this out. When they got through the condenser pressure had not dropped appreciably and more precious ammonia had disappeared. Two more 100-lb. drums were required to bring the liquid back to the same level in the glass as it was before they started purging.

After being told about the sudden disappearance of the ammonia, the builder's man, who had arrived, inquired regarding the leaks experienced. The men were confident there were none, and the expert convinced himself that they were right. He next turned his attention to the expansion coils to see if by any means some of the liquid could have accumulated in these. After a thorough inspection and several pump-outs he satisfied himself that the trouble was not at this point.

About this time his attention was called to the excessive condenser pressure. He was also informed that

the condenser had been purged until they had wasted about 200 lb. of ammonia without relief and that they were sure air or foul gas in the condenser was not the cause of the trouble. He decided to have a look at the condenser.

It was a warm, humid day, and he noticed that half of the condenser was sweating. He was surprised to find that all the coils (the condenser was of the double-pipe type) were cold, indicating that they were not working. The coils of the other half of the condenser were very hot. Evidently something was wrong with the section that was cold.

The condenser was divided into two sections. Each had its own liquid header. A branch from each header connected with the liquid line to the receiver, and a stop valve was provided for each section so that in case of emergency one section could be shut off and half of the condenser kept in operation.

The expert decided to shut off the hot section by closing the valve in the branch to the liquid line. The liquid would then accumulate in the hot section, the pressure would probably increase and start the other section working. This will work out well where a condenser is airbound. He notified the engineers that he was going to make an experiment and told them not to let the condenser pressure rise too high, but to slow down the machine or shut it down entirely in case the pressure went much higher.

The valve in the branch connection had been shut off only a few minutes when he noticed that the pulsations in the discharge line began to decrease in number, indicating that the machine was being slowed down. The pulsations became fewer and fewer until they ceased. A few moments later one of the engineers informed him that the condenser pressure was nearly 250 lb. and that the relief valve would operate if they attempted to run it higher. The cold section was still as cold as ever. Evidently, other measures would have to be taken if they were to get it into action.

The valve in the branch from the section that had been shut off was opened again and the system put back in normal operation. The gas and liquid valves on each coil of the dead section were shut off and the coils pumped out. Gradually the liquid line in the gage-glass of the liquid receiver began to rise until it was full. There was still no frost on the coils of the dead section, which generally takes place about the time when the coils are nearly empty. Evidently, there was still considerable liquid in them.

The condenser pressure began to climb again, indicating that so much liquid had been pumped out of the dead section that the other section was being filled up in addition to the liquid receiver. Thinking that possibly something had lodged in the branch line from the dead section to the liquid line, he determined to test for this by reversing the flow in the branch line. This was accomplished by opening the liquid valves at the bottom of the coils, leaving the gas valves at the top closed.

As the pressure had been considerably reduced in the dead section by pumping down and as the pressure in the other section was excessively high, there was a large difference in pressure between the two sections and the natural tendency would be to cause a high velocity flow from one section to the other until the pressures were balanced. A few moments after he had opened the last liquid valve, the engineer informed him that the condenser pressure had dropped considerably below 200 pounds.

The gas valves at the tops of the coils were then opened and all the coils warmed up to the same temperature as those in the other section, indicating that they were now working well. The condenser pressure had dropped to 170 lb. and the liquid receiver was full.

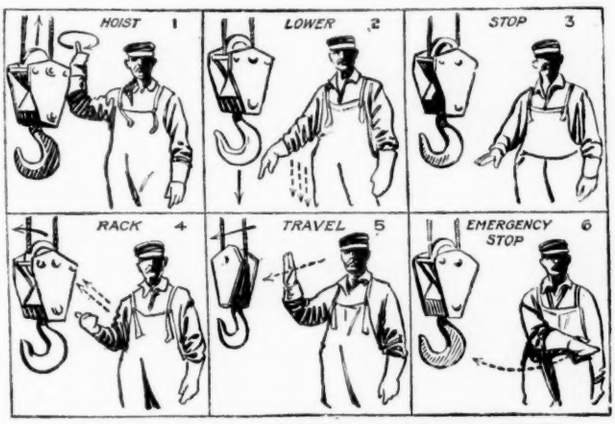
No further trouble was experienced. The following winter the expert received a letter from the chief engineer informing him that the cause of the trouble had been found. It was a disk in a valve placed in the branch line from the troublesome section in such a way that the flow through the valve tended to pull the disk against the seat. The disk had dropped off the stem squarely on the seat, practically shutting off the flow. When the flow had been reversed in the branch, the disk had been carried back toward the liquid header of that section and wedged in the tee where the branch was connected. Here it was found when the condenser was opened up and overhauled that winter.

Uniform Crane Signals

The Industrial Board of the Pennsylvania Department of Labor and Industry has adopted, among other safety standards, uniform crane signals. The same signals, which are illustrated in the accompanying cut, have also been recommended as a standard by the Safety Engineering Board of the Emergency Fleet Corporation. The signals are described as follows:

1. Hoist—Forearm vertical. Make small horizontal circles with the hand.

2. Lower—Arm extended, hand below hip, wave forearm downward.



UNIFORM CRANE SIGNALS, AS RECOMMENDED

3. Stop—Arm extended, hand level with hip. Hold position rigidly.

4. Rack—Arm extended, hand just above hip, fingers closed, thumb extended horizontally, jerk hand in direction of racking.

5. Travel—Forearm vertical, hand open. Wave forearm in direction of travel.

6. Emergency Stop—Arm extended, hand level with the hip. Move hand quickly to right and left.

The signals should be posted in all crane cages and should be observed only when they are given by the proper person.

Care of Heating and Ventilating Equipment—IV

By HAROLD L. ALT

In which the author describes the development of down-draft furnaces, enumerates their advantages over the up-draft type and tells how to obtain the best results in firing them.

BY SOME the up-draft grate is not considered the most satisfactory or the most efficient method of solving the combustion problem, and for this reason the down-draft boiler has been developed in numerous designs, some of which are shown in the illustrations and nearly all of which are patterned after the Hawley down-draft furnace. As has been pointed out, the smoke that results from the escape of unconsumed combustible gases can be avoided by igniting these gases when combined with sufficient oxygen. In an up-draft furnace it is hard (the Bureau of Mines experts say it is practically impossible) to get enough air up through the fuel bed to accomplish this end—hence the more or less successful results from the admission of air or both steam and air above the fire.

Someone conceived the idea long ago that if the direction of the draft was reversed, the unconsumed gases would be drawn down through the mass of burning fuel, insuring positive ignition and combustion. But difficulties developed, for the experiments showed that the heated gases drawn down through the grate instead of the cold air being drawn upward through them in the ordinary way, melted the grate bars. This trouble was overcome, however, by the use of a water-cooled grate, a set of pipes with water circulating through them. Further experiments showed that if the coals dropping through the upper grate with comparatively wide openings were caught a short distance below on a second, updraft, grate with a small air supply from below, the small incandescent coal would then be consumed and would furnish an auxiliary safeguard against any unconsumed gas and smoke finding their way to the stack. This then is, in brief, the modern down-draft furnace, although all down-draft boilers do not necessarily have the second or lower grate. As a general thing the down-draft boiler must be set higher than the up-draft in order to accommodate the two grates and the ashpit, and this naturally results in raising the firing doors by a like amount; for this reason some engineers do not like them, claiming that they are harder to fire, but this objection can usually be remedied by the proper use of a raised platform along the firing aisle.

Down-draft furnaces can be built into steel firebox boilers, as shown in Fig. 1, under horizontal return-

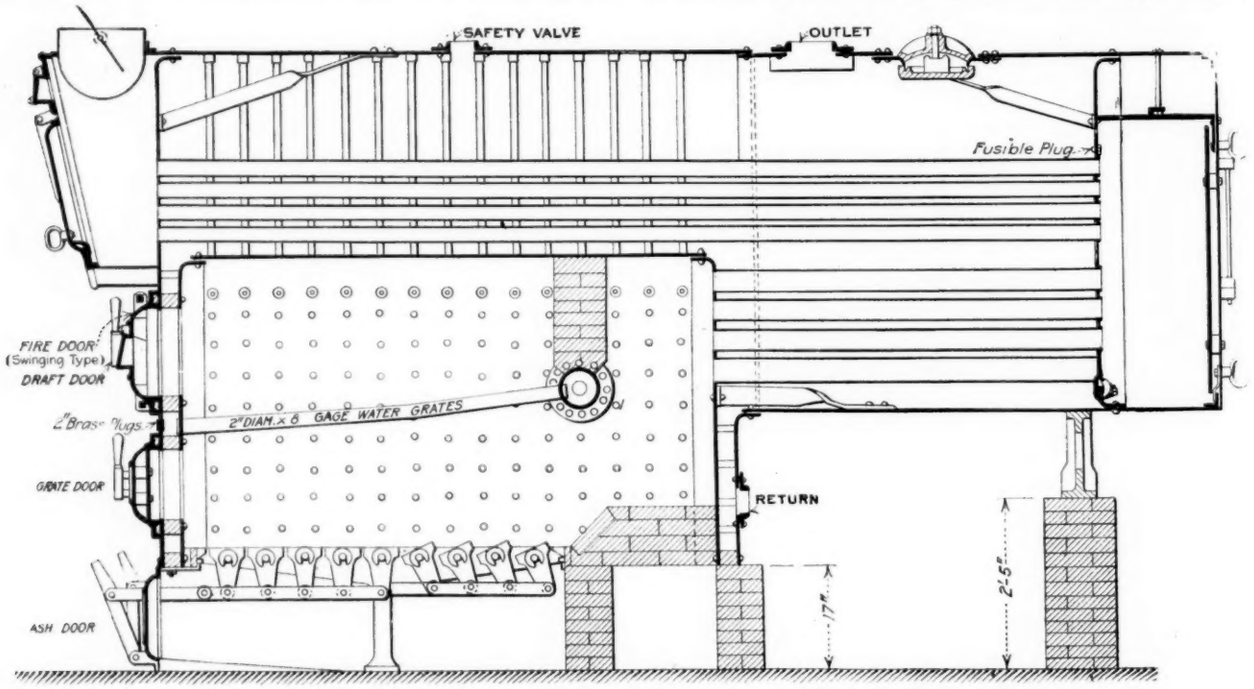


FIG. 1. DOWN-DRAFT FURNACE BUILT INTO A LOCOMOTIVE-TYPE BOILER

tubular boilers, and many cast-iron boilers are so constructed, some of them being 150 to 200 hp. rating. Two types are shown in the illustrations Figs. 2 and 3. Firing a down-draft furnace correctly is not a matter entirely devoid of skill, but on the other hand better results can be obtained with down-draft than with updraft furnaces with the same degree of skill, but one who is extremely careless or ignorant can produce a lot of smoke from either. As an example of this a common laborer in stoking the fires on one of the best makes of down-draft boilers and breaking up the clinkers with his slice bar produced a dense black smoke from the stack and the bad condition lasted in decreasing intensity during 10 or 15 minutes or until the principal portion of the gases had passed off. On the other hand, between stoking and cleaning periods no smoke was noticeable even with this inexperienced fireman.

The requirement for the smokeless combustion of bituminous coal is that the volatile matter be thoroughly mixed with air while at a high temperature, and this is easily accomplished in the down-draft furnace because the distilled gases are drawn directly down through the incandescent bed of fuel and, following the same paths as the air, become thoroughly intermixed and are ignited in the bed of fuel through which they are passing, the volatile carbon being oxidized to CO_2. This operation differs from that of the mechanical stoker, in which the coal is supplied at a nearly uniform rate and the gases are developed continuously, dependence being placed upon the heat of the combustion chamber to keep them ignited until their combustion is complete.

Smokeless combustion can be attained at all times with a well-designed down-draft furnace when properly fired, and may be practically smokeless even with improper firing. The fuel bed, however, after a time is likely to cake and fuse together so that the draft is hindered and the rate of combustion lowered. When this occurs the fire must be loosened up by running the slice bar under it along the grate bars "clear to the back" of the furnace and the fuel bed raised slightly, cracking the caked fuel and reopening the air passages. The movement of the bar, however, should be limited to the extent of "cracking the fuel bed" only, and its action should not affect the whole fuel bed any more than is necessary. This barring if carried out over the whole grate area will also cause a loosening of the ash on the upper grate bars, and will cause small pieces of the partly burned fuel to drop to the lower grate where they are completely burned. After the barring the coal on the lower grate will lie in irregular piles and should be leveled off to an even thickness with a rake or hoe. After this is done the upper fire is clean with ample air opening and the bottom grate has its fullest charge of incandescent coal ready to ignite any stray gases that may escape from the upper grate. In other words, both grates are in the best condition to prevent smoke and therefore this is the time to apply a fresh charge of fuel to the upper grate. If the fresh fuel is applied before the slice bar is used and the fire given a thorough cleaning, not only will smoke result, but the condition of the fire will cause the fresh fuel to burn unevenly, giving rise to more troubles.

Troublesome clinkers should never collect on a down-draft grate even when burning the dirtiest of screenings. Frequent use of the slice bar over the entire grate area, as described, will break up the ash as soon as it is formed, and while the ash after falling through to the lower grate may ball together into small clinkers, this fire is thin and easily cleaned so that little trouble should be experienced with clinkers. The removal of ashes from a down-draft furnace should be the operation preceding that of barring or slicing because removing the small clinkers and ash from the lower grate results in leaving holes in the fire and puts this bed of fuel into poor condition. Therefore after removing the ashes and clinkers the rest of the fuel and ash should be spread evenly over the lower grate and the fire on the lower grate can then be renewed by slicing the upper grate as explained. Thus to coal a down-draft furnace it is necessary to begin by removing the ash and clinker from the lower grate, level off the remaining fuel on the lower grate, bar or slice the top grate, smooth off the lower grate a second time and then—and not till then—put on fresh coal. A certain well-known smoke inspector gives the following short and concise rules for operating down-draft furnaces without making smoke:

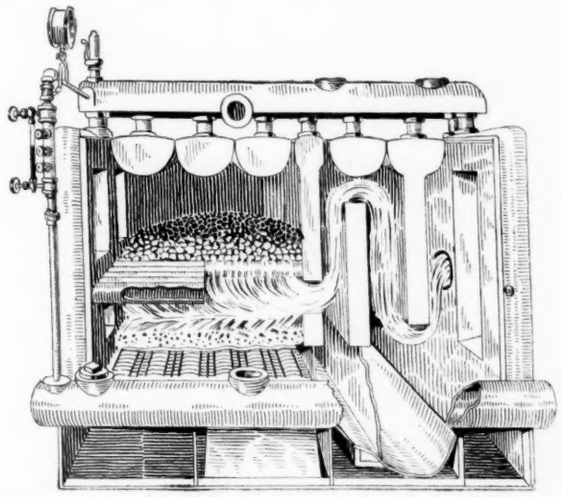


FIG. 3. SMALL BOILER WITH DOWN-DRAFT FURNACE

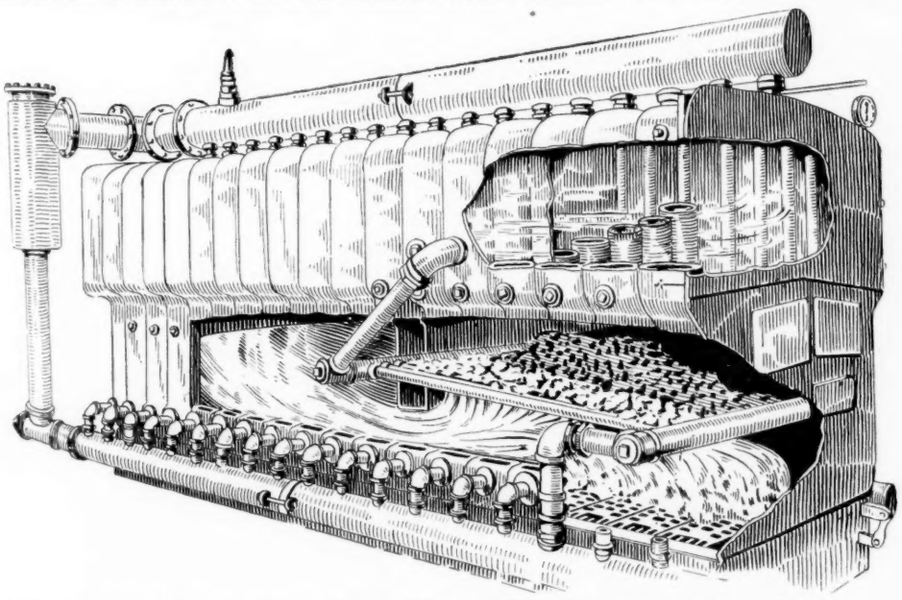


FIG. 2. DOWN-DRAFT FURNACE IN LARGE CAST-IRON SECTIONAL BOILER

To start a fire, place wood on top and bottom grates. Light the wood. Put coal on the top grate. When the coal begins to burn, build up the fire on the upper grate until it is 8 in. thick. Never put coal on the lower grate. When the fire is started, don't fire any coal bigger than your fist. Carry a thick fire, 8 in. or more on the top grate. Keep the fire level by firing on bright spots.

Don't permit holes to burn in the fire. Don't poke the top of the fire. Slice the fire on the top grate by running the slice bar along the grate under the fire. Keep the fire on the bottom grate level and clean. Keep the ashpit clean. Clean the flues once a day. Another method of starting a fire in a down-draft furnace is to place on the upper grate, coal broken to a size not larger than the fist, then wood on top of this and paper waste or shavings on top of all, also place wood and shavings on the lower grate and light both fires at the same time, leaving the upper door open. After the fire is well ignited, keep the upper grate covered with coal. As soon as the coal begins to cake, stoke with a slicing bar on the upper grate. Never put any fuel on the lower grate and keep the fire on this grate clean. It will be noticed that "laying" the fire in the upper grate is simply a reversal of the method employed for an up-draft grate.

Power-House Report Forms

If all power plants were alike it would be easy to draw up report forms that would suit one plant as well as another. But plants are not all alike; record and report forms are therefore of almost infinite variety. Seldom are forms well adapted to one plant suitable in others. Those shown in Figs. 1 and 2 are so simple yet so all-inclusive that it is believed they will assist many who are interested in the important subject of power-plant reports and records. They are used by one of the large chemical manufacturers in the East.

Someone has said that a path would be worn to the door of a house in which lived a man who knew more about a certain subject than anybody else in the world. That may be true, but the trouble lies in the fact that the world is slow in finding out a man's knowledge until after he is dead.—*Marine Engineering.*

Ref. Eng. Dept. Cir. Letter 114.

WEEKLY POWER HOUSE REPORT

For Week Ending June 28, 1918.

BOILER ROOM

				COST
Anthracite Coal Used		lbs. at $	p. ton in the pile	$
Bituminous "	455300	lbs. at $	6.32 " " " "	1439 75
Water Evap. from 211 °Temp. to 145	lbs. press. 4133000	lbs. at $	16.00 p. million lbs.	66 13
Operating Labor (Regular number of Men per 24 hrs.	9)			270 45
" Supplies				21 23
		Total Cost of Steam		1797 56

Operating Load Factor, ave. for last 6 mos.	92	%	this week	101 %
Rate of Evaporation " " " "	8.12	lbs.	" "	9.07 lbs.
Cost of Steam per 2,000 lbs. " " " "		cents	" "	86.98 cents
Ashes taken out 45,530 lbs. actual	10	% ash; by analysis of coal	unknown	%
Peak Load Factor of Boilers operating for 15 min.	120	% Minimum L. F. for 4 hrs.	60	%

COAL IN BOAT CULLEN #11

ENGINE ROOM

		TOTAL COST	%	TO ELECTRICITY COST
Operating Labor (Regular number of Men per 24 hrs.	6	$ 179 91	80	158 33
" Supplies, except Oil		10 35	80	8 28
Oil: 12 H gal. Cyl. Oil;	gal. Eng. Oil; Air gal. other Oil	11 95	"	9 56
13 L				
	Total	$ 220 21		$ 176 17
	Engine Room Cost not charged to Electricity	$ 44 04		
	Steam used for Electricity, at 23 lbs. per KW. hr.	736800 lbs.		$ 320 45
	Total Cost of Electricity			$ 496 62
	Total Electricity Generated 31600 KW. hrs.			

Operating Load Factor of Generators, ave. for last 6 mos.	48	%	this week	42 %
Cost of Electricity per KW. hr., " " " "		cents	" "	1.57 cents
Peak Load Factor of Generators operating for 15 min.	80	% Minimum L. F. for 4 hrs.	13	%

POWER HOUSE REPAIRS

	BOILER ROOM	ENGINE ROOM
Cost of Repair Labor	$ 8 70	$
" " " Supplies	10 45	1 40
Total for this week	$ 19 15	$ 1 40
Total for this 6 mos. to date	$ 656 88	$

FIG. 1. WEEKLY POWER HOUSE REPORT—ALL ITEMS

WEEKLY REPORT ON POWER DISTRIBUTION

For Week Ending June 8, 1918.

	STEAM LBS.	STEAM COST	ELECTRICITY K.W.HRS.	ELECTRICITY COST	POWER BY BELT, WATER, AIR, MISCEL.	TOTAL COST
Electricity	736800	320 45				
Factory	733316	318 94	27370	430 10	368 69	1113 73
Acid Plant	708195	308 02	2780	43 70	364 68	716 40
Plant	378930	164 82	1450	22 82		187 64
Rendering Plant						
Extraction Plant						
Glue Plant						
Bone Black Plant						
Bag Factory						
Total	2557241		31600	496 62	739 37	2017 77
Total Water Evaporated	4133000					
Bal. to Belt Power, Water, etc.	1575758	685 33			685 33	
Engine Room Cost not charged to Electricity					44 04	
Total Cost to be accounted for by Belt Power, Water, Air, and Miscel.					729 37	

FIG. 2. REPORT (WEEKLY) SHOWING DISTRIBUTION OF POWER

Ferrochem Feed-Water Treatment

According to the reports of boiler-inspection and insurance companies, more than half of the boilers inspected by them are affected by burned plates, defective tubes, tubes leaking at the headers, incrustation and scale, and internal and external grooving, all of which can be traced to the feed water.

Many methods have been devised for the prevention of scale formation in steam boilers, most of which depend upon chemical treatment of the water either before or after it enters the boilers. Mechanical removal of the scale from the boiler-heating surfaces after it has formed is also largely practiced.

A machine for the nonchemical treatment of feed water, known as Ferrochem, has been placed on the market by the Ferrochem Co., Ltd., of 30 Church St., New York City. The device, shown in Fig. 1, consists of a hollow ring casting made of an alloy of iron and four balls of the same material, the latter traveling in the hollow path in the body of the casting, through which they are forced by the feed water as it is pumped through the machine. As these balls are forced through their path of rotation, fine particles of the metal from the balls and machine body are liberated through abrasion and mingle with the water passing through the machine.

The manufacturers of this machine urged the publishers of *Power* to install one in order to test it out in their own power plant. This was done, the installation is shown in Fig. 2, and the following results were obtained in a six-months' trial:

During that time no other agency has been used to prevent the formation of scale, and when the boilers were last opened for cleaning, the scale was found to be lying loose in the tubes and was so soft that it could be crushed with the hands. In this condition, it was easily washed out, no mechanical cleaning of the tubes being necessary.

A machine may be installed as shown in Fig. 3 with a bypass so that there may be no interruption to the boiler feed while changing the balls or in case it is necessary to cut out the machine.

This machine is furnished in proper capacity to care for one or more boilers, as the case may be, on a 90 days' trial, under the guarantee that no new scale will form and that existing scale will be softened and loosened so that it can be readily removed. Also that pitting and corrosion will be prevented and that the cause of priming will be removed. If the machine is unsatisfactory and fails to perform according to the guarantee given, it will be removed and the user will be held under no obligation for the time it has been in use.

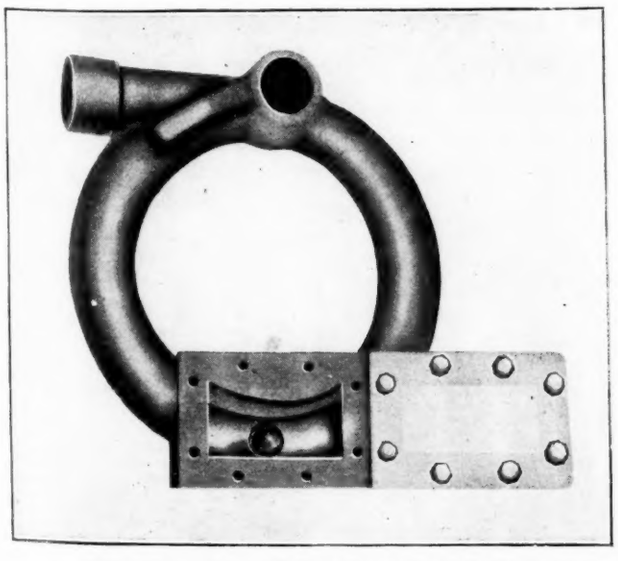


FIG. 1. FERROCHEM TREATING APPARATUS

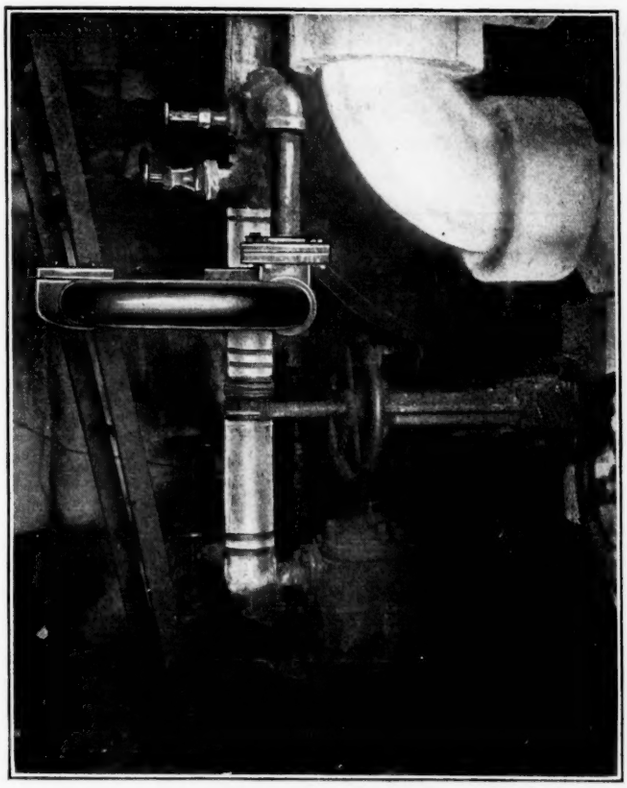


FIG. 2. FERROCHEM INSTALLATION AT THE HILL BUILDING, NEW YORK CITY

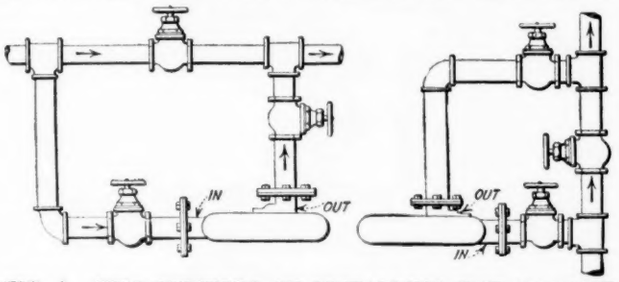


FIG. 3. TWO METHODS OF INSTALLING THE MACHINE

As the result of a series of experiments on twist drills, recently undertaken at the engineering experiment station of the Illinois University, the following lubricants are recommended: For tool steel—lard oil, machine oil, turpentine, soda-water, kerosene; for soft steel—lard oil, machine oil, soda-water; for cast iron—dry or compressed air; for brass—dry or paraffin oil; for aluminum—kerosene, soda-water, and aqualine and soda-water. For steel, boil together lard oil one-third and soda-water two-thirds; for steel—heat together borax 7 lb., and water 40 gal., and when cool add 7 gal. of lard oil; for steel—a thin drilling compound, almost water—enough to make smooth and to prevent rust.

Method for Determining Resistance Used for Starting Various Types of Motors

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A simple method is given for determining the ohmic value of the resistance used for starting series-, shunt- and compound-wound direct-current motors and wound-rotor induction motors under various load conditions.

MANY methods of more or less complicated nature have been employed for obtaining the correct ohmic values of the resistance which should be used for starting and accelerating various types of direct-current and alternating-current motors. The practical man of affairs usually has neither the inclination nor the time to decipher any of these methods, but instead uses some rough and ready rule with which he may be familiar. This article gives a series of tables for various types of motors, which will be accurate enough for all practical purposes and can be used by anyone who is familiar with the fundamentals of electric motors. The following data are given in the order named:

Table I recommends the number of resistance divisions to use for various types and sizes of motors under light and heavy starting duty, when using either manual

TABLE I. NUMBER OF RESISTOR DIVISIONS FOR STARTING DIFFERENT TYPES OF MOTORS

	Suggested Number of Resistor Divisions for Accelerating Motors										
	Magnetic Control								Manual Control		
	Shunt Motor					Wound-Rotor Ind. Motor					
Horsepower of Motor	Full Load	Half Load	Centrifugal Pump	Compound Motor	Series Motor	Full Load	Half Load	Centrifugal Pump	Shunt Motor	Compound Motor	Series Motor	Wound-rotor Ind. Motor
1–3	1	1	1	1	1	1	1	1	2	2	2	2 per phase
5–10	2	1	2	2	2	1	1	1	4	4	4	2 per phase
15–25	3	2	2	2	2	2	1	2	4	4	4	2 per phase
30–45	4	2	3	3	2	2	2	2	4	4	4	3 per phase
50–75	4	3	3	3	2	3	2	2	7	7	7	3 per phase
80–125	5	3	4	4	3	4	3	3	7	7	7	4 per phase
135–275	6	4	4	4	3	5	3	4	9	9	9	4 per phase
300–500	7	4	4	4	3	6	4	4	9	9	9	4 per phase

or magnetic control. Divisions for giving low torque points are not included in these numbers. This should be added to the values given, if low torques are required.

Table II gives constants with which to easily find the ohmic values of each division of a starting resistor for direct-current shunt motors, or wound-rotor induction motors, which are started under full load.

Table III gives the same data as Table II, but for compound-wound motors having 50 per cent. shunt and 50 per cent. series excitation.

Table IV gives the same data as Table II, but for series-wound motors.

Table V gives the same data as Table II, but for motors that do not require more than 50 per cent. normal torque during the accelerating period.

Table VI gives the same data as Table II, but for induction motors whose resistance is cut out of circuit unbalanced, as shown in Fig. 5.

Tables VII is different from the previous tables, in that it gives, first, the ohmic values and, second, the current values at which each resistor section should be short-circuited.

Figs. 1 to 6 inclusive show elementary connections of the various motors, the order in which the resistors are short-circuited, and the symbols used in the tables. The letters, A_1, B_1, C_1, etc., on the figures represent the resistor divisions in the order in which they are calculated, but in the reverse order in which they are cut out of circuit. The digits 1, 2, 3, etc., represent the order in which the contactors close.

In Tables II to VI the letters A and X represent multipliers for use in obtaining the ohmic value of the resistance section A_1, B_1, C_1, etc., Figs. 1 to 6, and M represents a constant by which the normal current is multiplied to obtain the maximum current peak during acceleration. Examples will be worked out under the five tables to illustrate their application.

Example 1: Use Tables I and II and Fig. 1. Given a 25-hp. 230-volt shunt motor, to determine the ohmic value of the starting resistor when using a magnetic controller and starting under full load.

The full-load current $I = 93$ amp., as obtained from the name-plate, or by the formula $I = \frac{855 \times hp.}{E}$.

Normal resistance $R = \frac{E}{I} = \frac{230}{93} = 2.473$ ohms.

Normal resistance is an ohmic value which, if connected across line potential, will allow 100 per cent., or full-load, current to flow. In this and the following prob-

TABLE II. RESISTOR-DIVISION CONSTANTS FOR DIRECT-CURRENT SHUNT MOTORS AND WOUND-ROTOR INDUCTION MOTORS

Horsepower of Motor	Number of Resistor Divisions for Accelerating																								Figure Nos.
	1			2			3			4			5			6			7			8			
	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	
1–3	0.25	....	2.9	0.122	2.02	2.00	0.084	1.7	1.7	0.063	1.53	1.53	0.05	1.42	1.42	0.042	1.35	1.35	0.036	1.3	1.3	0.032	1.27	1.27	1 & 4
5–10	0.25	....	3.0	0.12	2.09	2.09	0.081	1.75	1.75	0.061	1.56	1.56	0.048	1.44	1.44	0.041	1.37	1.37	0.034	1.31	1.31	0.031	1.28	1.28	1 & 4
15–25	....	....	....	0.115	2.15	2.15	0.078	1.78	1.78	0.058	1.58	1.58	0.047	1.47	1.47	0.039	1.39	1.39	0.034	1.34	1.34	0.029	1.29	1.29	1 & 4
30–45	....	....	....	0.11	2.23	2.23	0.074	1.83	1.83	0.056	1.62	1.62	0.044	1.49	1.49	0.037	1.41	1.41	0.032	1.35	1.35	0.028	1.3	1.3	1 & 4
50–75	....	....	....	0.10	2.42	2.42	0.066	1.94	1.94	0.049	1.7	1.7	0.039	1.56	1.56	0.032	1.46	1.46	0.028	1.4	1.4	0.024	1.35	1.35	1 & 4
80–125	....	....	....	....	....	....	0.056	2.12	2.12	0.041	1.83	1.83	0.033	1.65	1.65	0.027	1.54	1.54	0.023	1.46	1.46	0.020	1.4	1.4	1 & 4
135–275	....	....	....	....	....	....	0.05	2.24	2.24	0.036	1.9	1.9	0.028	1.71	1.71	0.023	1.58	1.58	0.02	1.5	1.5	0.017	1.43	1.43	1 & 4
300–500	....	....	....	....	....	....	0.042	2.4	2.4	0.031	2.02	2.0	0.024	1.79	1.79	0.02	1.65	1.65	0.017	1.55	1.55	0.014	1.48	1.48	1 & 4

TABLE III. RESISTOR-DIVISION CONSTANTS FOR 50 PER CENT. COMPOUND MOTORS

Horsepower of Motor	Number of Resistor Divisions for Accelerating																								Figure Nos.
	1			2			3			4			5			6			7			8			
	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	
1–5	0.32	....	2.38	0.18	1.44	1.73	0.132	1.30	1.51	0.106	1.23	1.38	0.091	1.17	1.30	....	....	....	....	....	....	....	....	....	2
5–10	0.28	....	2.62	0.17	1.47	1.85	0.118	1.40	1.58	0.095	1.30	1.40	0.074	1.27	1.35	0.063	1.20	1.30	0.054	1.19	1.25	....	....	....	2
15–30	....	....	....	0.162	1.65	1.90	0.119	1.40	1.62	0.09	1.33	1.46	0.073	1.27	1.37	0.065	1.2	1.30	0.059	1.17	1.25	....	....	....	2
35–75	....	....	....	0.147	1.72	2.12	0.107	1.50	1.73	0.084	1.38	1.54	0.072	1.28	1.43	0.058	1.26	1.36	0.050	1.22	1.32	....	....	....	2
80–150	....	....	....	....	....	....	0.098	1.6	1.82	0.076	1.45	1.60	0.066	1.33	1.48	0.053	1.3	1.40	0.045	1.26	1.35	....	....	....	2
160–300	....	....	....	....	....	....	0.100	1.58	1.86	0.08	1.41	1.63	0.066	1.33	1.50	0.056	1.28	1.42	0.05	1.23	1.35	....	....	....	2

lems, the normal value of the resistance is used only as a basis for determining the value of the different divisions of the starting resistor.

Referring to Table I and looking down in the first column, "Horsepower of Motor," will be found the value 15-25. The value 25 corresponds to the size of the motor I. In these columns the values of $A = 0.078$, $X = 1.78$, and $M = 1.78$. To find the value of the resistance section A_1, Fig. 1, multiply the normal resistance R by the multiplier A, or $A_1 = AR = 0.078 \times 2.473 = 0.193$ ohm. The value of B_1 is obtained by multiplying A_1 by the multiplier X, in this problem, $B_1 = A_1X = 0.193$

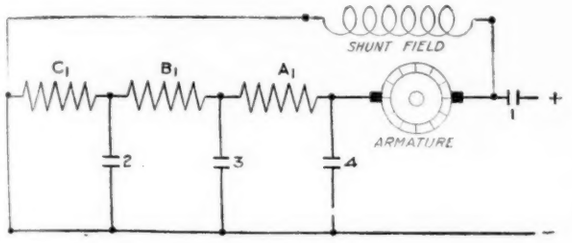


FIG. 1

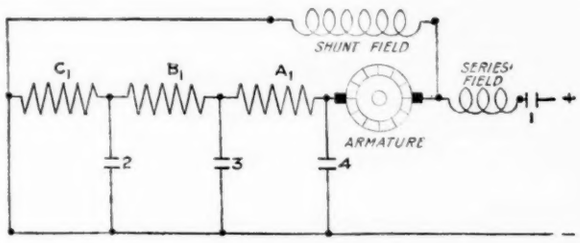


FIG. 2

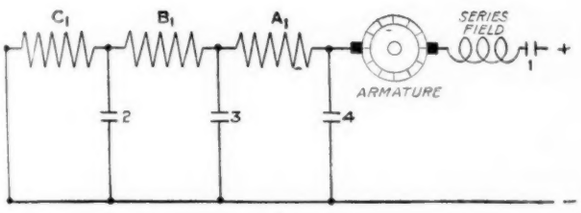


FIG. 3

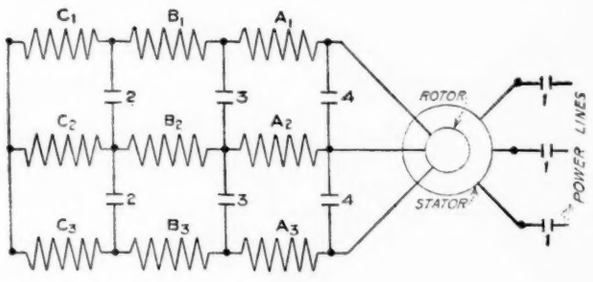


FIG 4

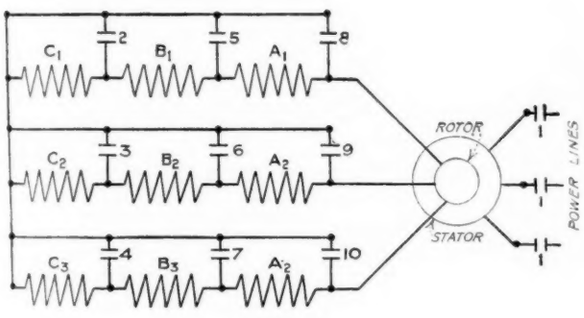


FIG. 5

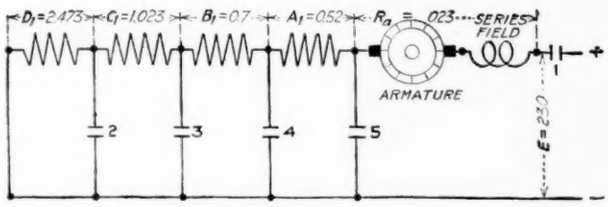


FIG. 6

SCHEMATIC DIAGRAMS FOR STARTING-RESISTANCE CONNECTIONS OF DIFFERENT TYPES OF MOTOR

we have in the problem. Opposite this value in the next column, under the heading "Magnetic Control, Shunt Motor, Full Load," is found the value 3, which is the number of divisions that the starting resistance should be divided into. Referring to Table II and looking under the heading "Horsepower of Motor," find 15-25, and follow to the right to column A, X, M, under 3. This value 3 corresponds to the number of divisions the resistance is to be divided into, as found in Table

$\times$ 1.78 = 0.344 ohm. The ohmic value of section C_1 is obtained by multiplying B_1 by the multiplier X, from which $C_1 = B_1X = 0.344 \times 1.78 = 0.612$ ohm. This gives a total external resistance of $A_1 + B_1 + C_1 = 0.193 + 0.344 + 0.612 = 1.149$ ohm. The internal resistance is assumed to be 0.236 ohm.

The maximum current obtained during acceleration with this value of resistance and divisions, is equal to the normal current $I = 93$ amp. times the multiplier

TABLE IV. RESISTOR-DIVISION CONSTANTS FOR SERIES MOTORS

Horsepower of Motor	Number of Resistor Divisions for Accelerating																								Figure Nos.
	1			2			3			4			5			6			7			8			
	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	
1-5	0.38	....	1.87	0.24	1.15	1.47	0.18	1.10	1.32	0.15	1.06	1.24	1.32	1.04	1.18	....	....	....	....	....	....	....	....	....	3
5-10	0.32	....	2.25	0.21	1.36	1.62	0.154	1.23	1.42	0.13	1.17	1.30	0.10	1.15	1.25	0.085	1.12	1.22	0.074	1.11	1.18	....	....	....	3
15-35	0.32	....	2.27	0.21	1.35	1.66	0.16	1.20	1.45	0.123	1.18	1.34	0.10	1.13	1.27	0.091	1.11	1.20	0.084	1.08	1.17	....	....	....	3
40-100	0.31	....	2.60	0.185	1.54	1.82	0.14	1.34	1.52	0.111	1.25	1.38	0.10	1.2	1.30	0.079	1.17	1.26	0.068	1.14	1.23	....	....	....	3
125-300	....	....	....	0.20	1.45	1.75	0.157	1.27	1.48	0.123	1.22	1.36	0.104	1.17	1.29	0.09	1.14	1.25	0.079	1.11	1.20	....	....	....	3

TABLE V. RESISTOR-DIVISION CONSTANTS FOR DIRECT-CURRENT SHUNT MOTORS AND WOUND-ROTOR INDUCTION MOTORS STARTING UNDER LIGHT LOAD

Horsepower of Motor	Number of Resistor Divisions for Accelerating																								Figure Nos.
	1			2			3			4			5			6			7			8			
	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	A	X	M	
1-3	0.40	....	2.0	0.19	2.57	1.28	0.12	2.02	1.0	0.09	1.75	0.88	0.072	1.6	0.8	0.06	1.5	0.75	0.052	1.43	0.72	0.045	1.37	0.68	1 & 4
5-10	0.40	....	2.0	0.18	2.63	1.32	0.116	2.06	1.03	0.086	1.78	0.90	0.069	1.63	0.82	0.057	1.52	0.76	0.048	1.44	0.72	0.042	1.38	0.70	1 & 4
15-25	0.35	....	2.2	0.17	2.7	1.35	0.112	2.12	1.06	0.082	1.82	0.91	0.065	1.65	0.83	0.053	1.53	0.77	0.046	1.46	0.73	0.040	1.40	0.70	1 & 4
30-45	0.33	....	2.8	0.145	3.16	1.58	0.096	2.37	1.18	0.07	2.0	1.0	0.055	1.78	0.90	0.045	1.64	0.82	0.038	1.54	0.74	0.033	1.47	0.74	1 & 4
50-75	....	....	....	0.135	3.24	1.62	0.072	2.40	1.20	0.06	2.02	1.0	0.048	1.8	0.90	0.039	1.65	0.82	0.033	1.55	0.78	0.029	1.48	0.74	1 & 4
80-125	....	....	....	0.121	3.42	1.72	0.076	2.51	1.26	0.05	2.10	1.05	0.043	1.85	0.93	0.035	1.70	0.85	0.03	1.59	0.80	0.026	1.51	0.76	1 & 4
135-275	....	....	....	....	....	....	0.066	2.66	1.33	0.048	2.19	1.1	0.037	1.92	0.98	0.03	1.75	0.88	0.026	1.64	0.82	0.022	1.54	0.77	1 & 4
300-500	....	....	....	....	....	....	0.056	2.86	1.43	0.04	2.32	1.16	0.03	2.0	1.0	0.025	1.82	0.91	0.021	1.69	0.85	0.018	1.60	0.80	1 & 4

$M = 1.78$; that is, maximum starting current $= MI = 1.78 \times 93 = 166$ amp. This maximum peak is obtained on the first point of the controller if the resistor is laid out according to the table.

Example 2: Use Tables I and II, and Fig. 4. Given a 25-hp. 220-volt three-phase wound-rotor induction motor starting balanced; that is, equal sections of resistance are cut out of each phase on each point of the controller. Let the full-load secondary current equal $I_s = 93$ amp. (assumed). The rotor current varies for different voltages and speeds, so that no specific rule can be employed for determining it. The secondary current is usually given on the name-plate of the motor, but can be determined by measuring the rotor voltage between slip rings, with the rotor stationary and rated voltage applied at the stator terminals. Call this voltage E_s then full-load secondary current $I_s = \frac{430 \times hp.}{E_s}$. Normal ohms $= R = \frac{250 \times hp.}{I_s^2}$.

Since I_s is given in this example, normal ohms $R = \frac{250 \times 25}{93^2} = \frac{6250}{8649} = 0.722$.

In Table I under the heading, "Magnetic Control, Wound-Rotor Induction Motor, Full Load," for a 25-hp. machine, the suggested number of resistor divisions for accelerating is 2. Then referring to Table II in Column No. 2, the value of $A = 0.115$, $X = 2.15$ and $M = 2.15$ is given for 25-hp. motor. In Fig. 4 resistor section $A_1 = A_2 = A_3$, likewise $B_1 = B_2 = B_3$ and $C_1 = C_2 = C_3$. In this problem the resistor is cut out in two steps; consequently, the C sections of the resistor will be left out and the "Y" connection considered as made at 2. Therefore, at starting No. 3 contactors close first and cut out the B sections of resistance, and then contactors No. 4 close and short-circuit all the external resistance out of the motor circuit.

TABLE VI. RESISTOR-DIVISION CONSTANTS FOR STARTING WOUND-ROTOR INDUCTION MOTORS UNBALANCED

Horse-Power of Motor	Number of Resistor Divisions per Phase: 2			3			4		
	A	X	M	A	X	M	A	X	M
1–10	0.15	5.7	1.5	0.08	2.9	1.3	....	....	....
15–25	0.15	5.7	1.5	0.08	2.9	1.3	....	....	....
30–45	....	....	....	0.06	3.5	1.5	0.06	2.1	1.3
50–75	....	....	....	0.06	3.5	1.5	0.06	2.1	1.3
80–125	....	....	....	0.06	3.5	1.7	0.06	2.1	1.5
300–500	....	....	....	0.05	3.7	1.7	0.05	2.3	1.5

Example 3: Use Tables I and VI and Fig. 5. Given the same motor as in Problem 2, starting at full load, but with unbalanced resistor, and manual control. The normal ohms will be the same in both problems; that is, $R = 0.722$. Referring to Table I under "Manual Control," column headed "Wound-Rotor Induction Motor," for 25-hp. motor a two-division per phase resistor is recommended. This means that the resistor will have six sections, instead of nine, as shown in Fig. 5, with the "Y" connection at points 2, 3 and 4. Then, with two divisions per phase and starting unbalanced, contactor 5 will close first and cut out section B_1. Then, 6 is closed, cutting out section B_2, etc., until the last point, No. 10, closes and cuts all the resistance out of circuit. This gives seven points of acceleration. In Table VI, under "Two Resistor Divisions per Phase" is found for a 25-hp. motor, $A = 0.15$, $X = 5.7$ and $M = 1.5$. Therefore $A_1 = AR = 0.15 \times 0.722 = 0.108$ ohm, $B_1 = XA_1 = 5.7 \times 0.108 = 0.616$, and the total external ohms per phase $= A_1 + B_1 = 0.108 + 0.616 = 0.724$. Maximum secondary accelerating current $= MI_s = 1.5 \times 93 =$ 140 amp., and the maximum primary current during acceleration $= MI_p = 1.5 \times 66 = 99$ amperes.

Example 4: Use Tables I and III and Fig. 2. Given a 25-hp. 230-volt compound motor starting under full load with magnetic control. Full-load current $I = 93$ amp. and normal ohms $R = \frac{230}{93} = 2.473$. Table I. "Magnetic Control" under "Compound Motor" recommends a two-division resistor. Table III for 25-hp. under "2" gives $A = 0.162$, $X = 1.65$ and $M = 1.9$. Therefore, $A_1 = AR = 0.162 \times 2.473 = 0.041$ ohm, $B_1 = A_1X = 0.40 \times 1.65 = 0.66$ ohm, and the total external ohms $= A_1 + B_1 = 0.40 + 0.66 = 1.06$. The

Calculating the value of the resistance sections as for the shunt motor, $A_1 = A_2 = A_3 = AR = 0.115 \times 0.722 = 0.083$ ohm, $B_1 = B_2 = B_3 = A_1X = 0.083 \times 2.15 = 0.178$ ohm, and the external ohms per phase $= A_1 + B_1 = 0.083 + 0.178 = 0.261$. Maximum secondary current during acceleration $= MI_s = 2.15 \times 93 = 200$ amperes.

The full-load primary current will equal 66 amp. as obtained from the name-plate or from the formula for a three-phase motor,

$$I_p = \frac{1000 \times hp.}{E_p \times 1.732} = \frac{1000 \times 25}{220 \times 1.732} = 66 \text{ amp.}$$

where I_p equals the primary current per terminal and E_p the full volts applied to the motor terminals, equals line volts. Then the maximum primary current $MI_p = 2.15 \times 66 = 142$ amp. In this problem if the resistor had been cut out in three steps $C_1 = C_2 = C_3$ would equal B_1X; likewise if a fourth point was used, $D_1 = D_2 = D_3 = C_1X$.

In all cases, except for starting centrifugal pumps, which is taken care of in Table VII, outside of the first point, which is found by multiplying the normal ohms R by the constant A, the ohmic value of the succeeding point of resistance is found by multiplying the preceding point by the constant X.

TABLE VII. RESISTOR-DIVISION AND CURRENT CONSTANTS FOR DIRECT-CURRENT SHUNT MOTORS AND WOUND-ROTOR INDUCTION MOTORS STARTING CENTRIFUGAL PUMPS AND FANS

Horse-power of Motor	Resistor Divisions and Maximum Accel. Current Peak: A	B	C	D	E	M	A	B	C	D	E	M	A	B	C	D	E	F	M	Constants	Figure Nos.
1–10	0.32	.....	.....	.....	....	2.3	0.11	0.42	.....	....	....	1.55	0.062	0.14	0.48	.....	....	....	1.25	Res. points; max. current	1 & 4
	0.65	.....	.....	.....	....	....	0.79	0.55	.....	....	....	....	0.83	0.72	0.50	.....	....	....	....	Minimum accel. current	
15–25	0.11	0.40	.....	.....	....	1.65	0.058	0.13	0.46	....	....	1.35	0.033	0.064	0.14	0.49	....	....	1.20	Res. points; max. current	1 & 4
	0.81	0.56	.....	.....	....	....	0.85	0.74	0.52	....	....	....	0.90	0.82	0.75	0.49	....	....	....	Minimum accel. current	
30–45	0.09	0.36	.....	.....	....	1.9	0.052	0.12	0.44	....	....	1.45	0.032	0.06	0.13	0.47	....	....	1.3	Res. points; max. current	1 & 4
	0.85	0.60	.....	.....	....	....	0.88	0.76	0.53	....	....	....	0.92	0.83	0.73	0.51	....	....	....	Minimum accel. current	
50–75	0.045	0.11	0.40	....	....	1.65	0.03	0.056	0.13	0.44	....	1.4	0.018	0.032	0.06	0.13	0.47	....	1.3	Res. points; max. current	1 & 4
	0.92	0.81	0.56	.....	....	....	0.90	0.87	0.75	0.53	....	....	1.0	0.92	0.83	0.73	0.51	....	....	Minimum accel. current	
80–125	0.044	0.11	0.39	.....	....	1.7	0.025	0.05	0.12	0.43	....	1.5	0.017	0.03	0.058	0.13	0.46	....	1.35	Res. points; max. current	1 & 4
	0.93	0.81	0.58	.....	....	....	1.0	0.90	0.78	0.54	....	....	1.0	0.92	0.85	0.74	0.52	....	1.00	Minimum accel. current	
135–500	0.024	0.047	0.11	0.41	....	1.6	0.016	0.028	0.052	0.12	0.44	1.45	0.013	0.017	0.03	0.058	0.13	0.46	1.35	Res. points; max. current	1 & 4
	1.0	0.92	0.80	0.56	....	....	1.0	0.94	0.88	0.76	0.53	....	1.0	1.0	0.92	0.85	0.74	0.52	....	Minimum accel. current	

maximum current during acceleration $= MI = 1.9 \times 93 = 177$ amperes.

Example 5: Use Tables I and IV and Fig. 3. Given a 25-hp. 230-volt series motor starting under full load with magnetic control. Full-load current $I = 93$ amp. and normal ohms $= R = \frac{230}{93} = 2.473$. Table I, "Magnetic Control," "Series-Motor" column, recommends a two-division resistor. Table IV for a 25-hp. machine under "2" gives $A = 0.21$, $X = 1.35$ and $M = 1.66$. Therefore $A_1 = AR = 0.21 \times 2.473 = 0.52$ ohm, $B_1 = A_1X = 0.52 \times 1.35 = 0.70$ ohm and the total external ohms $= A_1 + B_1 = 0.52 + 0.70 = 1.22$. The maximum current during acceleration $= MI = 1.66 \times 93 = 154$ amperes.

Example 6: Use Tables I and V and Fig. 1. Given a 25-hp. 230-volt shunt motor, starting light with magnetic control. Full-load current $I = 93$ amp., and normal ohms $R = \frac{230}{93} = 2.473$. Table I, for "Magnetic Control," under "One-half Load" recommends a two-division resistor. For starting light use same values as for one-half load. Table V for 25-hp. under "2" gives $A = 0.17$, $X = 2.7$ and $M = 1.35$. Therefore, $A_1 = AR = 0.17 \times 2.473 = 0.42$ ohm, $B_1 = A_1X = 0.42 \times 2.7 = 1.134$ ohms, and the total external ohms $= A_1 + B_1 = 0.42 + 1.134 = 1.554$. Maximum current during acceleration $= MI = 1.35 \times 93 = 126$ amperes.

Example 7: Use Tables I and V and Fig. 4. Given a 25-hp. 220-volt wound-rotor induction motor starting light with magnetic control, balanced resistor. As shown in Example 2, $R = 0.722$ ohm. Table I for "Magnetic Control" in "One-half Load" column for 25-hp. wound-rotor induction motor recommends a one-division resistor. Table V for 25-hp. motor under "1" gives $A = 0.35$ and $M = 2.2$. Therefore, $A_1 = AR = 0.35 \times 0.722 = 0.253$ ohm, equals the external ohms. The secondary current during acceleration $= MI_s = 2.2 \times 93 = 205$ amp., and the maximum primary current during acceleration $MI_p = 2.2 \times 66 = 145$ amperes.

Example 8: Use Tables I and VII and Fig. 1. Given a 25-hp. 230-volt shunt motor driving a centrifugal pump starting with magnetic control. Full-load current $I = 93$ amp. and normal ohms $R = \frac{230}{93} = 2.473$. Table I, for "Magnetic Control," in "Centrifugal-Pump" column recommends a two-division resistor. In Table VII it will be seen that for each motor size two sets of values are given. The top row gives the constants to multiply the normal ohms R by, to obtain the ohmic values of the different sections of resistor A_1, B_1, etc., and the multiplier M for obtaining the maximum accelerating current. In the lower row the values corresponding to a given size motor are constants for obtaining the current value when each section of resistance should be short-circuited. What each row of values corresponds to is given on the right-hand side of the tables. In the problem under consideration a two-division resistor is recommended. By referring to Table VII and following along the resistor-division-constant row for a 25-hp. motor, in the left-hand column of the table is found the value of $A = 0.11$, $B = 0.40$ and $M = 1.65$. If the foregoing had been a three-division resistor for a 25-hp. motor, then the values would be found in the middle section of the table, which gives $A = 0.058$, $B = 0.13$, $C = 0.46$ and $M = 1.35$. Likewise the constant for a four-division resistor is found in the third section of the table. Underneath these values are found the constants for determining at what current value the contactor should close, which for a two-division resistor $A = 0.81$, $B = 0.56$. Therefore, $A_1 = AR = 0.11 \times 2.473 = 0.272$, $B_1 = BR = 0.40 \times 2.473 = 0.989$, and the total external ohms equals $A_1 + B_1 = 0.272 + 0.989 = 1.261$. In the calculations for the resistor divisions for starting a centrifugal pump, the value of each section is obtained by multiplying the normal ohms R by the constant corresponding to that division instead of multiplying the ohmic value of the preceding divisions by X to obtain the value of the succeeding section, as in the previous problems.

The first accelerating contactor closes and short-circuits 0.989, and should close when the line current equals $BI = 0.56 \times 93 = 52$ amperes. The second accelerating contactor closes and short-circuits 0.272 ohm, and should close when the line current equals $AI = 0.81 \times 93 = 75$ amp. The maximum current during acceleration $= MI = 1.65 \times 93 = 153$ amperes.

Example 9: Use Tables I and VII and Fig. 4. Given a 220-volt three-phase 25-hp. wound-rotor induction motor driving a centrifugal pump and starting balanced with a magnetic controller. Assuming a full-load secondary current, $I_s = 93$ amp. as in Example 2, then normal ohms R will equal 0.722. Full-load primary current I_p will also equal 66 amp., the same as in Example 2. Table I for magnetic control of wound-rotor induction motor in "Centrifugal-Pump" column recommends a two-division resistor. Table VII for 25-hp. motor and a two-division resistor gives $A = 0.11$, $B = 0.40$ to determine the ohmic value of the resistor divisions, and $M = 1.65$ for the maximum current peak, with the minimum accelerating current corresponding to $A = 0.81$ and $B = 0.56$. Therefore, $A_1 = AR = 0.11 \times 0.722 = 0.079$, $B_1 = BR = 0.40 \times 0.722 = 0.289$ ohm, and the total external ohms per phase $= A_1 + B_1 = 0.079 + 0.289 = 0.368$.

The first accelerating contactor that closes and short-circuits 0.289 ohm should close when the line current $= BI_p = 0.56 \times 66 = 37$ amp. The second and last accelerating contactor closes and short-circuits 0.079 ohm, should operate when the line current $= AI_p = 0.81 \times 66 = 53$ amp. The maximum primary current during acceleration $= MI_p = 1.65 \times 66 = 109$ amp., and the maximum secondary current during acceleration $= MI = 1.65 \times 93 = 153$ amperes. If the motor has a low power factor, then the current values at which the contactors should close, as calculated in the foregoing, should be increased approximately 10 per cent.

Example 10: Use Tables I and IV and Fig. 6. Given a 25-hp. 230-volt series motor starting with magnetic control. Two low-torque points are required in the starting resistor in addition to those used for acceleration, such that on the first point 50 per cent. and on the second point 100 per cent. full-load current will be obtained at standstill of the motor. The resistance of the motor armature is assumed to be equal to 0.23 ohm. Full-load current equals $I = 93$ amp.; then normal ohms $R = \frac{230}{93} = 2.473$. Table I, "Magnetic Control" recom-

mends a two-division resistor for accelerating under full load. Therefore two divisions for low torque and two divisions for accelerating make four divisions total to be divided as follows: From Example 5 resistor $A_1 = 0.52$ ohm and $B_1 = 0.7$ ohm. Normal resistance $R = 2.473$ ohms will allow 100 per cent. full-load current to flow when 100 per cent. full-line voltage is applied to its terminals, or in this case 230 volts. This is what the total resistance of a circuit will have to be on the low-torque point of the controller to allow 100 per cent. full-load current to flow through the motor at standstill. This circuit will be made up of five sections of resistance; namely, D_1, C_1, B_1 A_1 and the resistance of the armature and series-field winding R_a, Fig. 6. Therefore $C_1 = R - (B_1 + A_1 + R^a) = 2.473 - (0.7 + 0.52 + 0.23) = 1.023$ ohms, as shown in Fig. 6.

If $R = 2.473$ ohms allows 100 per cent. full-load current to flow, then a resistance $= 2R = 2 \times 2.473 = 4.946$ ohms will allow only 50 per cent. full-load current to pass through the motor. Therefore, in Fig. 6 $D_1 = 2R - (C_1 + B_1 + A_1 + R_a) = 4.946 - (1.023 + 0.70 + 0.52 + 0.23) = 2.473$ ohms. Hence in Fig. 6 with only contactor No. 1 closed, 50 per cent. full-load current, or 46.5 amp., will flow with the motor at standstill.

Example 11: Use Tables I and IV and Fig. 3. Given a 25-hp. 230-volt series motor starting under full load with magnetic control. Required, a resistor to be used for reversing the motor at 150 per cent. full-load speed and limit the current to 150 per cent. full-load value. Under this condition the motor will generate about 160 per cent. counter-electromotive force, which, added to 100 per cent. line voltage, makes 260 per cent. line voltage. This voltage is equal to $2.6 \times 230 = 600$ volts. The normal full-load current equals 93 amp. as in Example 5; then 150 per cent. full-load current equals $93 \times 1.5 = 140$ amp. Therefore the total ohms R must equal $\frac{600}{140} = 4.3$. For accelerating, a two-division resistor will be required, as in Example 5, and in addition to this a third division will be required to limit the current to 150 per cent. full-load value during reversing. Referring to Example 5, $A_1 = 0.52$ ohm, $B_1 = 0.70$ ohm and assume the armature and series-field resistance $R_a = 0.23$ ohm; then $C_1 = R - (A_1 + B_1 + R_a) = 4.3 - (0.52 + 0.70 + 0.23) = 2.85$ ohms.

It will thus be seen that the essence of this article is included in the seven tables, and the remainder is simply an explanation of these tables. Table I suggests the number of resistor divisions which have been found to give good results, and by means of the constants given in the remaining tables, one may quickly determine the ohmic values for a resistor containing any reasonable number of divisions.

Care in the Operation of Small Turbines

By J. A. MAC MURCHY

Engineer, Small Turbine Department Westinghouse Electric and Manufacturing Company.

The small turbine is subject to greater neglect, because of its size, than large main units. In the following the author points out the parts of small turbines that should receive particular attention.

OPERATING engineers should understand thoroughly the apparatus which they are supposed to take care of. They should have a conception of the manner in which each device is supposed to function. Most turbine builders furnish books or pamphlets with instructions for the care and operation of their machines, and while these instructions may not cover all possible contingencies, they are at least sufficiently well illustrated to enable the operator to get a clear understanding of the machine. Too often these books are lost. There should be a definite place in each engine room for keeping all the instruction books instead of permitting the men to carry them around in their pockets or put them in their lockers. Too frequently, the books are kept in the office of the manager or the superintendent, and the operating men do not know of their existence.

Our small turbines, and I believe almost all others, are equipped with governor valves actuated directly by the governor without any form of relay, and with this arrangement it is important that the operators see to it that the valve is on its seat before the governor has reached the limit of its travel. This can usually be determined when the machine is at rest by taking off the governor spring and pulling out on the weights until the valve can be felt to come on its seat. It should then be observed that the governor still has considerable travel before reaching the limit of its movement. The setting of the governor valve should never be tampered with unless the operator is sure that it is necessary to make some change, and he should always make sure that the adjustment he makes does not prevent the governor from shutting it. Some engine-room operators who have been accustomed to handling gas engines are prone to think that governor valves should not close tightly, but in the case of turbines this would be a mistake.

No adjustment should be made to the governor valve-stem packing while the machine is running. The valve stem should be disconnected from the governor and the operator should make sure before starting the machine that the packing is not binding the stem and that it moves freely.

After any adjustment has been made to the packing on the quick closing throttle-valve stem, the device should be tested to see that it is not sticking.

Any form of emergency device should be tested periodically to see that it is operative; as it acts only in cases of emergency, it is usually the least reliable device on the machine because it so seldom moves. If a turbine is equipped with a device to shut it down should it overspeed to a predetermined amount, it is well to deliberately overspeed the turbine occasionally before shutting it down so as to be sure that this device works, but in all such cases care should be taken to observe the speed which the turbine attains and make sure that it does not greatly exceed the speed at which

the emergency stop is supposed to act. If the latter does not operate at the proper speed, it should be fixed before the machine goes in service again.

Governor valves are likely to become leaky in time, and they should be tested periodically to determine whether they are tight enough to safely control the machine. The best way to do this is to disconnect the valve from the governor, then, holding it on its seat by hand, observe the amount of steam that flows past the governor valve when the throttle valve is open. This could be done at some time when the cover is off the turbine. Needless to say, the governor valve should be tight.

If an emergency overspeed device operates and shuts down the turbine, it is usually an indication that the machine has overspeeded, although not always so. In any case the engine-room operators should find out the cause of the shutdown and not merely start the machine again, for instances are known where the overspeed device shut the machine down once when the turbine overspeeded but did not operate the next time. When an emergency device shuts down a turbine, the reasonable inference is that it has overspeeded, and the next time it is brought up to speed means should be at hand for determining the speed at which it is running and that it is under the control of the governor before the operator lets go of the throttle. If the governor does not control the speed properly, the unit should be shut down and fixed. Cases are known of emergency trips shutting down the turbine because of violent vibration induced from other machines. In a case like this the device should not be disconnected and rendered inoperative, but strenuous efforts should be made to fix it so that it will not be so sensitive to vibration and will still function when the turbine overspeeds.

Governor valve stems on turbines are usually small in diameter to avoid leakage and unnecessary friction. As a consequence they may become bent by being carelessly bumped by someone not appreciating the seriousness and not reporting it. Operators should make sure that the valve stems are not so injured that they will not move freely. This can always be tried out by hand when the machine is off the line, but often it is only necessary to glance at the stem to see that it is so injured as to render the governor inoperative.

Sometimes operating engineers feel that they can improve bearings by chipping in grooves in accordance with their fancy or some early experience they have had with reciprocating engines. This applies particularly to bearings designed for flood lubrication, which should under no circumstances have a groove of any kind on the pressure side of the bearing. I have in mind one case where the operator, to his horror, discovered that the manufacturer had neglected to put grooves in the lower half of the bearing and proceeded to chip in grooves, although the machine had been operating for nearly a year and the bearings showed no sign of wear. After the grooves had been added, the bearing lasted only a few hours, and the consequential damages were so serious as to render the machine inoperative for some time.

When any form of flexible coupling is used on high-speed apparatus, it is necessary that the elements so coupled together be in alignment. It is particularly important that the center lines of the shafts be coincident. If the machine begins to vibrate, the alignment should be checked up, for the fact that it was in alignment once does not necessarily mean it will remain so.

The condition of the lubricating oil requires a reasonable amount of attention, particularly in the matter of keeping water out of the oil. The kind of oil to use is rather a large question to discuss briefly but is, however, important.

A Nutty Power Plant

BY MANLY ORR

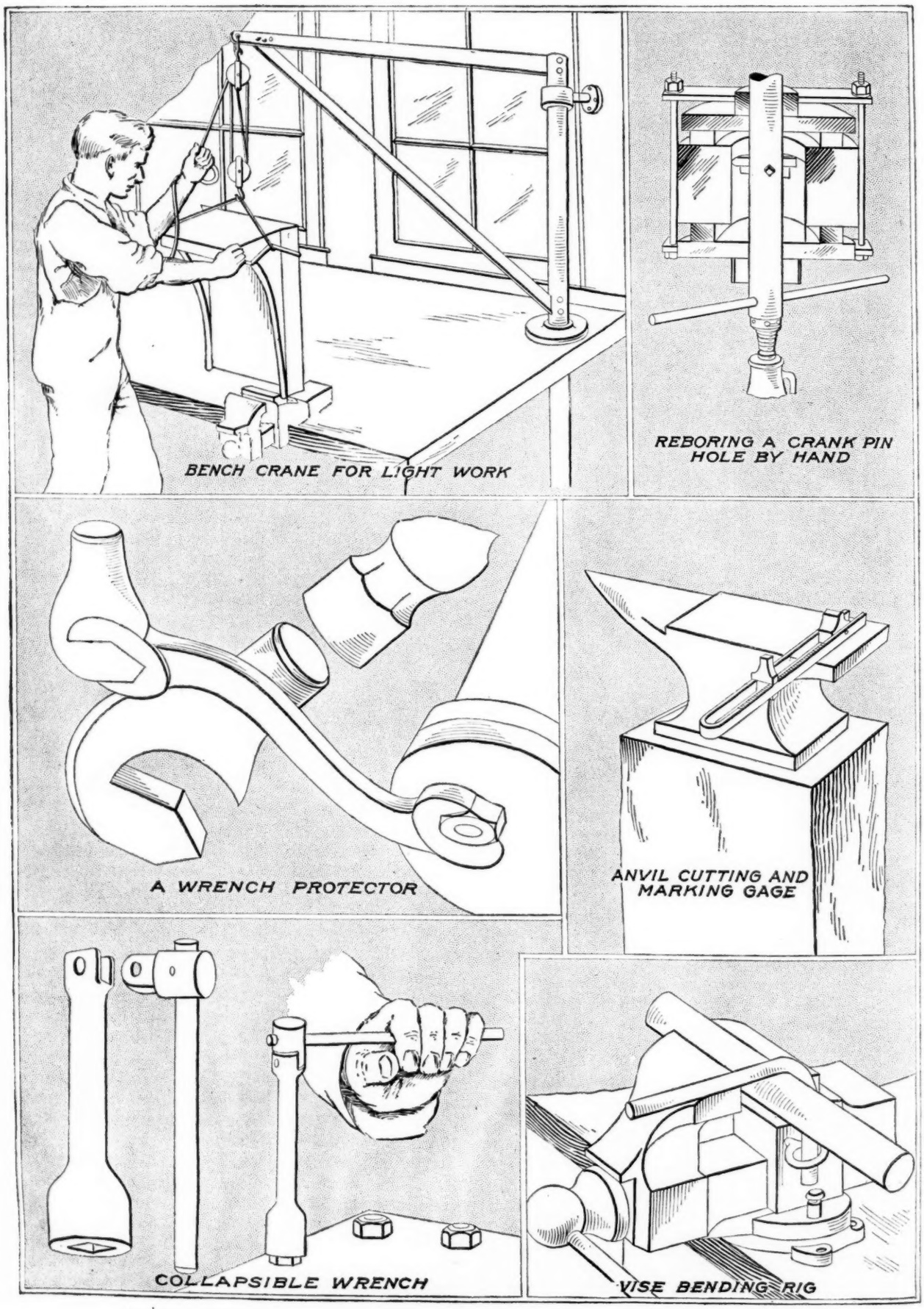
The chimney made a DRAFT on the furnace through the BANK of grates, and when the coal ACCEPTED THE DRAFT the fire went FLUEY and the boiler GOT HOT. The steam gage PUT UP ITS HAND, but the gage-glass said, "EVERYTHING SEEMS CLEAR TO ME," while the water claimed to be the only one acting ON THE LEVEL. "TRY US" said the three gage-cocks just as the blowoff OPENED UP ON THE QUESTION and then the safety valve called, "Everybody listen to me; I'm going to BLOW MYSELF." The rivets all shouted "HOLD ON NOW, HOLD ON," but the engine COMMENCED TO RUN and the flywheel STARTED A REVOLUTION.

"Don't come WITHIN A ROD OF ME, you old CROSSHEAD, called the piston. "Well you QUIT YOUR PUSHING," chimed in the cylinder; "can't you see I'M BORED?" "I hate being rushed about FROM PORT TO PORT by that ECCENTRIC guy," complained the valve. "Somebody ROUND HERE has got altogether too much BRASS," complained the crankpin. "FOR TWO PINS I'D KNOCK YOU SPINNING," replied the connecting-rod. At that the governor, which had "WEIGHTED" for an opportunity, MADE A LONG SPRING and managed to CUT-OFF the worst of the difficulty, but not before the engine was PRETTY WELL EXHAUSTED and the generator had become so EXCITED that it got all the motors and lamps ON THE WIRE and gave them the CURRENT EVENTS. The lamps offered some RESISTANCE but MADE LIGHT of it, but the motors were easily INDUCED to TURN in with the REVOLUTION, which spread rapidly FROM POLE TO POLE.

Every SINGLE PHASE of this SHOCKING affair was PASSED ON by the BOARD OF SWITCHES, who decided that every member of the entire plant was more or less NUTS.

To remedy dusty concrete floors, a surface treatment of some kind should be applied to remove the surface skin, which does not exceed $\frac{1}{32}$ in., or properly to treat it. One way is to grind the surface by hand or power as a terrazzo floor is polished. Other methods, says the *Engineer*, are to apply liquid coatings of various kinds. One of the most satisfactory treatments is with boiled linseed oil thinned with gasoline to such a consistency that it will penetrate the pores of the surface. If one coat does not cure the trouble generally two will. A second method is to clean the surface thoroughly and then apply a coat of silicate of soda or water glass, 40 deg. Baumé, diluted one part to six of water, to seal the surface. Then wash off the excess which opens out the pores again and apply a second coat.

Handy Kinks for the Power Plant


BENCH CRANE FOR LIGHT WORK
REBORING A CRANK PIN HOLE BY HAND
A WRENCH PROTECTOR
ANVIL CUTTING AND MARKING GAGE
COLLAPSIBLE WRENCH
VISE BENDING RIG

The Power-Plant Problem in South China

By HAROLD B. WILSON

The author is chief engineer and acting manager of the Kwangtung Electric Supply Co., Ltd., of Canton, China. He gives an idea of the power situation in that part of the country. Thus far only the roughest pioneer work has been done, and he is confident that Americans will play an important part in future development.

SEVERAL years ago a story was told about seven San Francisco Chinese business partners who had a safe built with seven keys. Each man carried a key and the safe could not be opened without using all seven. Whether the story is true or not, it illustrates one of the strongest Cantonese business traits. The stockholders in a Chinese business concern do not place implicit confidence in one another. That is not because they are dishonest, but because of an ancient custom called cumshaw or squeeze.

Any man that buys for others expects to get a commission; also, his employers or associates expect him to get it. This is very evident from the salaries they pay to managers of their own race. The mistrust arises largely because each man is afraid that some of his associates will get more than their share of cumshaw.

Another trait of the Cantonese is their inborn opposition to change and their desire to run their own affairs without outside interference or assistance. The Cantonese are given credit for being the most intelligent people in China, yet the development of Kwangtung has been much slower than that of North China. At the present time, barring commercial organization, there is not a single industry in Kwangtung controlled by foreign capital. In North China there are many.

Political Graft Hinders Business Growth

Another thing that affects business growth is the unreliable government. Every official makes just as much squeeze as he can. He does not want thanks or votes for favors. He wants cumshaw and he uses his power to get it.

There may have been officials in Kwangtung during the past few years, who have had the country's interest at heart more than their own, but the fact has not been made public through any reliable sources of information. Many of the military and civil governors have been bandits at earlier stages of their careers. There are millions of dollars of Chinese money here, in America, in the Straits Settlements and elsewhere that would be used to develop China if the present holders could get any kind of guarantee that officials would not rob them.

Enormous loans have been made to the Chinese government for industrial development, but probably only ten dollars out of every hundred has been honestly spent. One of the best solutions of the problem would be a combination of Chinese and foreign capital for developing such industries as railway and power plants, but of course this would ruffle the feelings of the Cantonese, who desires to run his own business.

Another thing that would help would be to give the Chinese students in America a good sound practical business and engineering training as well as a college education. There are hundreds of returned students in China either without jobs or doing work of very little industrial importance. There are plenty of places for these men if they had the practical training necessary to make good. Many of them have had opportunities and their failures have made it very difficult for the others to get a chance.

Favoritism Shown to Native Apprentices

Where the writer served his apprenticeship there were two Chinese boys doing the same thing. The foremen stood for no foolishness from the American apprentices, but anything went with the Chinese boys. As a result those boys got very little for the time they spent. While not finished engineers, the home boys were at least ready to start on their professional careers when they had finished their two-years' course. This does not mean that a good two-year apprenticeship course would equip the Chinese engineering graduate to do wonders in China, but five years would.

It would be wrong to give the idea that there is little business done in Canton. A copy of the Chinese Maritime Customs annual report would soon show the contrary. But the import and export business is at present a very small infant. However, the Cantonese love of business and money and their natural business instincts are bound eventually to overcome such obstacles.

Take the case of the Kwangtung Electric Supply Co. It had been struggling along on the hit-and-miss plan since about 1900. It had been a Chinese concern since 1909 but never paid a dividend until Tse Tsok Kai joined the company as assistant manager. He is an M.I.T. man who spent about eight years in the States going to school and working. He returned to China with the American idea of business, finally got into the concern and started it to paying dividends. Understanding his Chinese associates thoroughly (something a foreigner never does), he succeeded in getting them together and making a new start as the thing should be done.

Kwangtung Plant Equipment a Miscellany

Our present plant is about the most impossible one in existence. It was started with four 120-kw. vertical compound condensing steam sets, that were put in regardless of local conditions. Nine Diesel engines have been added, ranging from 200 to 500 hp., representing five different manufacturers. No one in particular is to blame for the crime, as the foreign engineers, not knowing how to handle the Chinese directors, were glad to take what they could get.

Last November our directors engaged a consulting engineer to design us a new plant and bought approximately $500,000 (gold) worth of American machinery. The first installation will be two 2500-kw. Curtis condensing turbines direct-connected to 2200-volt three-phase 60-cycle alternators and four 750-hp. Stirling boilers equipped with Murphy stokers and furnaces to

burn local North River coal. This coal is very fragile semi-anthracite of approximately the following analysis: Volatile matter, 13 per cent.; fixed carbon, 75 per cent.; ash, 12 per cent.; heat value, 12,000 B.t.u. per pound.

The condensers are to be extra large to give a 28-in. vacuum with cooling water at 80 deg. F. The station is designed for an ultimate capacity of 35,000 kw. including two 2500-, two 5000- and two 10,000-kw. units and sixteen 750-hp. boilers in eight batteries, four facing four with an overhead coal bunker between, storing 2000 tons.

This will be the first modern power plant in South China, and the first burning local Chinese coal. All other steam plants have boiler furnaces designed for bituminous coal and must get their supply from Japan. Japanese coal in Canton costs about $26 Hongkong currency or $20 gold per ton at the present time. North River coal will cost about $10 Hongkong currency.

Difficulties in Erecting Transmission Lines

Canton, the largest of the southern cities, has about 2,000,000 inhabitants. With the exception of the 2½ miles of bund along the river, there is not a decent street in the entire city. Practically all the modern buildings are located on the bund also. The streets are narrow, dirty and crooked, paved with stone slabs 14 in. wide by 6 ft. long, laid crosswise. The only drainage in the city is under these slab streets to various canals. Since the city is built on the delta of the Pearl River and has such poor drainage, it is very difficult to get good soil for setting poles. The crooked streets make it impossible to run straight lines. If the attempt is made to go over the houses to get straight lines, someone will build another story on his house and use the high-tension line to hang up the washing.

The other cities in South China are much like Canton, only worse. The largest of these is Fatshan, which has 500,000 inhabitants. The station consists of three 80-hp. Bolinder engines and one local oil engine belted to 60-kw. 2200-volt 60-cycle three-phase alternators. At present they are installing a 425-hp. Sulzer Diesel engine direct-connected to a 300-kw. alternator. Their business is beginning to grow.

There are plants at Shakee, Chenchun, Sheklung, Kongmon, Shuikwan, Tungkoon, Sainam, Taileung, Shuihing, Siulam, Yungki, Machen, Kungyick, Pakhoi and Kuikong, all in Kwangtung province. In the Kwangsi province there are plants at Nanning, Wouchow, Loochow and Kweilin. Very few of these plants are operated by steam. A great many are equipped with either European or local hot-bulb oil engines. Quite a number have gas-producer outfits, using charcoal to generate the gas. Our plant contains practically the only American machinery in the two provinces.

The reason for all these combustion-engine outfits is that the steam plants did not pay, owing largely to the necessity of using Japanese coal. Many of the plants are so located that the delivery of this coal is very costly. The Asiatic Petroleum Co. delivers crude oil to all accessible points at a reasonable figure. Charcoal is made locally.

These engines are doing pioneer work very well. Where they are given proper opportunity, the Chinese take good care of oil engines. They have learned that there is a limit to carelessness in making repairs on this type of machine. It either runs at a fairly high economy or it does not run at all. With small steam plants they do not do so well. There are too many parts of the unit scattered over the place for them to get a clear understanding of it. They make no more repairs than are absolutely necessary and the result is that the economy of operation suffers.

Chinese firemen are impossible. They do everything their own way and no amount of swearing will make them change. They throw all the coal in a heap and keep the fire-door open while they rake it round in place. Instead of firing light and often, they try to get enough coal on to last for a while so they can loaf.

No one ever seemed to take seriously the proposition of burning the local coal. The mine owners insisted they had good coal and got very much peeved at consumers for not using it; but they never carried out any experiments or engaged any experts to tell them how it could be done. The consumers insisted that the coal was merely black mud and could not be burned. Both were to blame. The largest consumers of coal in Canton are the steam-tug people and there is not a tug here equipped with a furnace designed to burn local coal. Owing to the high price of Japanese coal many of them are burning wood and many others are installing locally made hot-bulb oil engines.

War Increases Business of Power Stations

One thing that has affected the load of Chinese stations is the war. The price of kerosene has gone up to the sky and many Chinese are putting in electric lights in order to save money. We have a great many applications on file that we will be unable to fill until our new machinery is in operation. In this one instance the price of kerosene jarred John out of his old resistance to change. Our entire load has been built up without any soliciting, and we believe that, with our new station and new distribution scheme giving more satisfactory service, we can build up our load very rapidly by some intelligent soliciting. Most of our load is lighting and fans at present, but as Canton is an industrial city we hope to build up something of a motor load. There are a great many small printing offices, machine shops, mat- and cloth-weaving shops and pop factories here. Foot power at present is the most popular method of drive, but some of the small shops have gas, steam or oil engines or motors.

The future of power plants in South China looks very bright. Up the North and West Rivers there are numerous villages, ranging from a few hundred to five or six thousand inhabitants. Instead of living on isolated farms as they do in the States, the farmers live in little walled towns. This is done to afford protection against roving bands of pirates who live by pillaging the weak. Eventually, these villages will either have their own plants or get their electric supply from other larger villages.

Prior to the war the amount of American goods (barring tobacco and kerosene) sold in South China was very small and practically all of it was handled by foreign concerns. The Chinese are very friendly toward Americans. At the present time there are just two American engineering concerns with their own representatives in Canton, and there should be more. Every effort should be made toward strong trade with China.

EDITORIALS

After Effects of the War

THE war is won and the many things that we have been urged to do to win it are no longer necessary for that purpose.

But many of the things which the exigencies of war have emphasized as needful to make us powerful and efficient in times of stress are equally as potent to make us comfortable and contented and well-to-do in times of peace. We have tested the practicability of an organized and methodical regulation of our food and fuel supplies. The full benefit of this regulation, hastily organized as it was, with inadequate means and not without the questionable participation of the regulated, is not fully apparent, for it is impossible to see to what a degree of shortage, extortion and suffering the country might have gone without the encouragement and direction of producers and distributors and the restraint put upon speculation and profiteering by this emergency organization.

We have acquired habits of thrift and economy. We have learned to get along with less and save more. The meaning and significance of efficiency have become popularized.

In the power-plant field especially, the lessons of the war should be of particular permanent value. To save coal was worth while even under pre-war conditions. As the increased demands of speeding industries enhanced the price of fuel, economy in its use became more of a consideration. But when we got into the war ourselves and a combination of exceptional demands, inadequate railroad facilities and lack of man power resulted in such a coal shortage that it was "Save or Shut Down!" efficiency in the power plant took on a new importance. The man who could manage a boiler room so as to save ten or fifteen per cent. of the coal was in demand, the man with a suggestion looking to increased efficiency got a hearing, and apparatus of proved value in cheapening the production of steam or improving the processes in which it is used was installed up to the capacity of its makers to furnish it. Under the inspiration and supervision of the Fuel Administration, national, state and local, plants have been visited and owners, managers and operatives furnished with suggestions and instructions which have resulted in a very considerable diminution of the amount of fuel burned to do the same amount of work. The possibility of saving has been demonstrated. The fact of a sustained and considerable preventable waste has been proved.

An old New England engineer used to remark that when a man was losing money and did not know it, it did not worry him; but once let him wake up to the loss and it would keep him awake nights. The power-plant owner has now been made aware of his loss in many instances. He has been shown how simple a process it is to stop it. He has sensed, and others than the burners of coal are coming to realize it, that aside from all considerations of personal gain it is his duty as a contribution to the general efficiency, to the conservation of the collective resources, to maintain his power plant upon an efficient basis, and not to relapse into the old-time lack of interest when the pressure is relieved. The good work done in shortening the path between the engine room and the office during this period of enforced economy will have an important permanent effect upon the day-in and day-out efficiency of the average power plant.

The Care of Auxiliaries

THE old saying that a chain is no stronger than its weakest link is true of a power plant, either isolated or central station. How often is to be seen the spectacle of a large power unit lying useless because some small auxiliary, often a mere handful of metal, has failed to perform its function.

Too frequently, important auxiliary apparatus is located in dark, dirty, inaccessible places about a power house, as in crowded basements, where it is not easy or agreeable to give it the proper attention. The inclination to place too much stress on the main power unit and too little upon the equally essential auxiliaries is natural but unfortunate, and does not excuse neglect and the resulting certain trouble.

No amount of careful maintenance of the main unit will make up for neglect of the air pump or the circulating condenser pump or the boiler-feed pumps.

It is true that an accident to a one-thousand or thirty-thousand horsepower unit is of more interest, yet the total expense of a delay may be as great when caused by a small auxiliary as when resulting from damage to the prime mover.

Looking at the broad result of a shutdown and consequent interruption to the industrial processes dependent upon that power, the mere expense of replacing damaged parts is negligible compared to the loss resulting from curtailment of output. There is hardly a concern where the loss in wages alone would not equal the cost of repairing or replacing even major parts of the power apparatus. There are few operating men handling power equipment who realize the full losses involved in a serious shutdown. They vaguely realize that their employer or their employer's customers are losing some money, but of its amount they have not the slightest conception.

There are numerous plants whose processes depend upon having large quantities of water available supplied by relatively small turbine pumping units. While it is true that all plants should have reserve equipment, it is a fact that under present conditions where factories have doubled and trebled their output they are now using to its full capacity every bit of equipment they have and the only reserve they have is the expert mechanical ability of their men to make quick repairs or maintain adjustments so as to prevent shutdown.

One concern that uses large quantities of water delivered by small turbine-driven pumps, would lose in one day's loss of product enough money to pay for over half of its pumping equipment.

Less than six months ago it had more units in reserve than were necessary to maintain its output. Today with everything running it cannot produce all that the Government is asking of it.

Do you think its management would look favorably upon an engineer who failed to keep his turbine pumps in first-class shape? Would the superintendent of that concern who devotes most of his time to hard study and planning of processes, feel safe if he knew his engineers were merely wheel twisters who knew only how to start and stop their units and who devoted no time to a thorough study of their equipment so they would not only know every detail of its construction but what to do if an emergency arose?

No Profiteering Through Increased Price of Anthracite

IGNORANCE of the exact scope of the terms used in coal mining is likely to lead to misunderstanding in connection with the recent increase in the price of coal. The advance is ninety-five cents a ton to the consumer and is authorized by the Fuel Administration because of higher wages granted to the miners of anthracite. But people know that the miner does not receive an increase of ninety-five cents a ton in wages, and as a miner can easily produce several tons a day, a suspicion at once arises that the mine owner and the coal dealer are profiteering on a grand scale at the expense of the consumer.

Nothing could be farther from the truth. The explanation lies in the fact that the miners affected by the increase of wages are not merely the men who do the work of blasting down the coal and loading it on the cars. The increase applies to a large number of workers inside and outside the mine, all of whom are included by the general term "miners." The higher wages granted to these various classes of employees, it is claimed by the mine operators and allowed by the Fuel Administration, makes necessary an advance of ninety-five cents a ton and involves no increased profit to owner or dealer.

Electrically Applied Power In the Industries

THE Committee on Industrial and Domestic Power of the American Institute of Electrical Engineers, under the chairmanship of Captain Martindale, has adopted what promises to be a practical and workable plan for impressing the collective expert knowledge of a great scientific society upon the particular problems of individual industries. It is purposed to study the possibilities, advantages and best methods of applying the electric motor to machine tools, the manufacture of cement and the operation of passenger elevators. The first fruit of the committee's work is an excellent paper on Electric Motors in the Cement Industry presented by R. B. Williamson of the Allis-Chalmers Co., at the recent New York meeting of the Institute. The discussion of the plan of the committee brought out the idea that the electrical engineer, by reason of the ease with which the motored power can be measured and the flexibility of the electrical method, had frequently been able to improve processes of which he had had no previous knowledge.

The motor has grown to be an important feature of power-plant equipment, and will become increasingly so. The power-plant engineer and the master mechanic must add to their knowledge of belting and shafting, gears, rope drives and other methods of power transmission a knowledge of the electric motor such as will enable them to take advantage of its various characteristics, to select and adapt motors for and to particular situations and to diagnose and correct their operating difficulties. The Electrical Study Course which *Power* is publishing is offered in the hope that it will be useful to those of its readers who wish to inform themselves in this direction, and has reached the motor phase of the subject. Mr. Dudley's motor articles should also be helpful and have been the subject of many complimentary comments.

Saving Fuel in Short-Hour Service

THE campaign against excessive fuel consumption is going well but a good deal still remains to be done in attacking some of the short-hour applications of electricity from the efficiency standpoint.

An example of how every little helps occurs in the case of a large banking institution open about five hours daily, where the counters for customers' use in making out deposits, etc., are illuminated by sixteen twenty-five-watt lamps supplied off central-station lines. A study of the lighting conditions by an engineer shows that fifteen-watt lamps would perform sufficiently satisfactory service in the reflectors above these counters, especially if dusted daily or even three times a week. In a five-hour day this means a saving of eight hundred watt-hours, representing at least two pounds of coal and perhaps two and a half at the local panel boards.

A little extra study of these short-hour uses, even though they come off the central-station peak, is worth while at this time. In such institutions the air-washer service may be cut off a little earlier and started a little later than usual, to advantage, and the use of elevators on short downward trips of employees might well be curtailed. Engineers with banking establishments in hand for service will do well to go over these places with a fine-toothed comb in the interest of a better scheduling of power and lighting requirements; and we believe they will find their customers and employers responsive to the patriotic aspect of the situation in the majority of cases.

A good many firemen who are able to recite the fistic pedigree of Battling Bludsoe are uncertain as to whether Orsat designates a new tooth paste or a battlefield in France.

If William Hohenzollern were granting interviews just now, he would probably verify the statement that only a fool fails to profit by the experience of his fellowmen.

CORRESPONDENCE

In these and other columns "Power" wants to tell how you have decreased the fuel consumption in your plant. Since the fuel shortage, engineers have been thinking hard about conserving fuel. Thousands have made changes in equipment, in operating methods, and in modifications to boiler settings, etc., all of which have, in many plants, greatly cut fuel consumption. You owe it to the country to tell your fellow-engineers how you have saved coal. "Power" will pay for good articles that will help the other fellow save coal as you have saved it. Engineers must save at least 35 million tons this year. Let's have your story.

The United States Fuel Administration Through Advisory Engineer David Moffat Myers Seconds the Above Appeal in the Accompanying Letter

UNITED STATES FUEL ADMINISTRATION
BUREAU OF CONSERVATION
WASHINGTON D C
November 8, 1918.

Editor.
Power.
New York City.

Dear Sir:

Plants which have carefully followed the conservation recommendations of the U. S. Fuel Administration should now be able to report interesting facts about what has been accomplished.

We would like to ask your further co-operation with the Fuel Administration's work to the extent of publishing a notice in "Power" stating that at the request of the U. S. Fuel Administration you are inviting readers to write concerning the savings that have been made by following the U. S. Fuel Administration's recommendations and that as many of the letters received will be published as space conditions permit.

These letters should cover three questions.

1. What was done?
2. How was it done?
3. What results were obtained?

We believe that in this way, many interesting facts will be brought to light and feel certain that you will be rendering a valuable assistance to the fuel conservation program.

May we count on "Power".

Yours very truly,

UNITED STATES FUEL ADMINISTRATION,

David Moffat Myers

Advisory Engineer.

Can They Count Upon "Power"? It Is from Our Readers That They Want To Hear. We Shall Be Glad To Serve As the Medium

Toward Saving Coal

What Have You Done? How Did You Do It? What Results Did You Get?

Better Oil-Testing Methods Needed

In connection with Mr. Trinks' article on testing cylinder oil in the issue of Oct. 29, p. 644, the following experience, while it offers no solution, bears out the statement that better methods are needed.

The representative of a well-known oil-refining company visited our plant, asked a few questions and casually glanced over the different units and departed. In due time another appeared and introduced himself as a lubrication expert, and said he had been sent to conduct a lubricating test on our engines and asked, "When can we get started?" He said that the engine to be "experimented" on must first be taken apart and each part examined and measured and notes made as to its condition. We informed him that the engines were operated continuously and could not be taken down unless absolutely necessary, and as it happened they were all "doing business" that day. The expert then told us how often engines should be taken down for inspection, "regardless of circumstances," and worked himself into quite a rage over our methods of operation. Finally, he appealed to our officials, who declined to have the engines torn down, but said they would allow him to make any tests that he could while the engines were in operation.

In due time we were instructed to start using the new oil in the cylinder of one engine at the same rate of feed previously used. The expert visited us in a few days and cut the rate of feed about one-third, and as the engine did not show any immediate signs of distress, he seemed to consider it a great step toward

economy and bade us good-by. In three days he returned, and inquired about the engine, and we admitted that there were no signs of lack of oil, so he cut the feed again, making it about one-half the original quantity. We objected to this, and asked him how he could tell when nearing the danger point. He explained that due to special refining processes, etc., this oil had wonderful lubricating qualities and it seemed to be his idea that too little could not be used. He assured us that we were in no danger and again said good-by. The next day this engine suddenly began to show distress in every bearing and to lose speed. All hands were on deck, and everything possible was done to avoid a shutdown, but without avail. The piston and rings were dry and dragging hard, and the bearings all heated up quickly, causing it to stall.

We had to pump several gallons of common oil into the cylinder and run the engine with a light load for several days before getting it back to normal condition.

Needless to say that when the expert made his next call we were not testing oil on any engine and he was very indignant about it and even questioned our veracity regarding the performance of the engine. However, we had enough evidence to bar his experiments, and we have not seen or heard from him since. An engine in service is not a very good machine to try oil on, but if it must be done the expert should be compelled to stay with his test and not walk away leaving some one to reap the harvest from his sowing.

Philadelphia, Penn. T. A. MARSHALL.

I would very much like to hear of some method of testing cylinder oil as suggested by Professor Trinks.

One experience with a highly recommended cylinder oil was that inside of three months we had to replace the piston rings and rebore a cylinder. We changed to an oil that I had used with success in other places and had good results.

What bearing do superheat and high pressure have on cylinder lubrication? HERBERT B. BRAND.

Homestead, Penn.

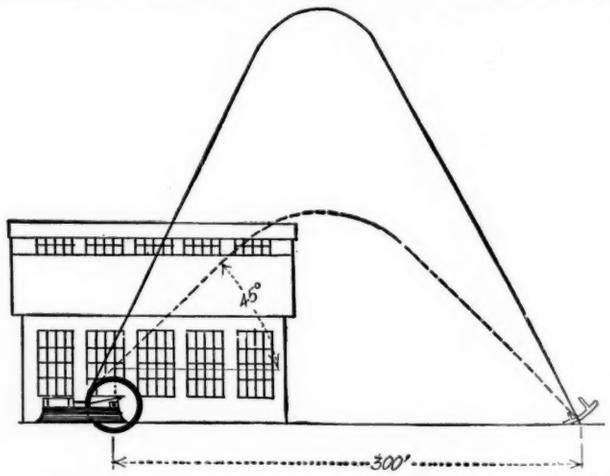
Did Flywheel Explode at Normal Speed?

The flywheel explosion described on page 516 in the issue of Oct. 8 was attended by circumstances that would appear a little unusual. One of the outstanding features is the statement that the initial rupture took place at the normal speed of the engine, "as evidence from the beater room and elsewhere tends to show." By this statement (in quotation marks), in the article referred to, presumably is meant that no unusual speed was observed at the driven machinery. It was also found that the engine was undamaged and would be ready to run when a new wheel was installed.

Without having any other information at hand than that contained in the article referred to, the writer would not wish this to appear as a contradiction of the statement that there was no abnormal speed, which of course is a probability; but it occurred to him that in connection with this accident there are some features which might prove that the wheel did run at a much greater speed than normal at the time the initial rupture took place. It is stated that the greater number of the fragments went upward, carrying the engine-room roof with them, and that two pieces adjacent to the joint landed a full block away. If we may conclude from this that these two pieces also made their departure through the roof, it is not clear how the disruption of the wheel could have been due to anything but overspeed.

A rough calculation of the velocity required to throw an object a horizontal distance of a full block, when its trajectory is a parabola of the most favorable inclination to reach this horizontal distance, would be a fair clue to the minimum speed the wheel rim must have had at the instant of rupture, since it is self-evident that the flying fragments cannot possibly have attained a greater velocity than they had while they were still a part of the revolving rim.

If we take, as a pure guess, the distance the pieces were found away from the engine at 300 ft., which would seem conservative for the length of a block, and the angle to the horizontal at which they were hurled



PROBABLE FLIGHT SOMEWHERE BETWEEN THE LINES

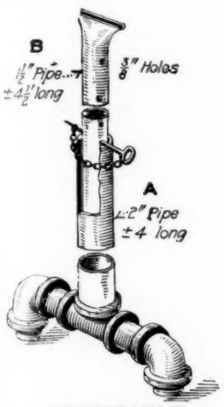
away at 45 deg., the velocity of the rim would have been at the least $60\sqrt{32.16 \times 300} = 5892$ ft. per minute, which for a 14½-ft. diameter wheel corresponds to $\frac{5892}{3.1416 \times 14.5} = 129\frac{1}{3}$ revolutions per minute.

This already would indicate considerable overspeed without taking into account the retarding influence of the roof on the flying fragments, which necessarily reduced their velocity and consequently their range. If the assumption of the distance is at all correct, an estimate of this kind might be considered as reasonable proof that there was excess speed. Of course, if the breaks in the engine-room roof tend to show that the upward course of the fragments was at a steeper angle than 45 deg. so that they reached a much greater height, as indicated by the solid line in the accompanying sketch, then there would appear to be no doubt that the engine temporarily raced. If breakage of the main belt took place first so that all the crank effort of the engine suddenly became available to speed up the wheel, it would take but a small period of time to develop sufficient centrifugal force to disrupt the wheelrim, especially so in view of the fact that it was a comparatively light rim with joints of the weakest type.

Hartford, Conn. H. J. VANDEREB.

Pipe Support or Standard

The illustration shows an adjustable prop made from pieces of old pipe and fittings picked from the scrap heap. *A* is a piece of 2-in. pipe about 4 ft. long with fittings attached. *B* is a piece of 1½-in. pipe about 4½ ft. long with ⅜-in. holes drilled through for a pin to pass through and rest on top of the large pipe, and is kept from falling out by a small chain and hook attached. Holes are drilled about 6 in. apart so that the prop can be extended or lowered to suit. The upper end of the pipe *B* may be formed to suit the use to which the prop is put. In this case it was heated and flattened to a wedge shape. This simple rig will be found handy in places where there is lifting and loading of heavy articles to be done.



ADJUSTABLE SUPPORT

J. O. McDONNELL.
Toronto, Ont., Canada.

Use of Exhaust-Steam Injector

I read with interest the article on the subject of exhaust-steam injectors in the issue of Oct. 8, page 521, and also your request for information concerning the behavior of these injectors in use, in the issue of Oct. 29, page 644.

Several years ago I had considerable experience with this type of boiler feeder in both stationary and marine work and found it to be highly efficient and dependable, but beyond pressures of 85 lb. gage it requires the assistance of a small quantity of live steam. In a power station erected for trolley-car service, there were four 300-hp. engines equipped with two Schaeffer & Budenberg exhaust-steam injectors operated in conjunction with two feed-water heaters delivering water to the boilers against a pressure of 95 lb. with exhaust alone. The water, however, was supplied under a pressure of 40 lb. gage, and at no time was there any difficulty with the feed; furthermore, there was sufficient exhaust steam over the requirements of the instruments to heat the water to a temperature of 160 to 200 deg. F. After a period of use it was necessary to take the injectors out of service because the oil separators or extractors eliminated but a small portion of the grease, the remainder being delivered into the boilers, which became badly fouled with oil and in several cases began to blister.

In a number of plants which I visited or had interest in during the years the complaint was always the same, and this gave this type of boiler feeder a "black eye." At a later date, however, opportunity was given me to make a close study of the exhaust-steam injector on a boiler operating at 80 lb. gage, installed in connection with which was a good oil separator, and both gave entire satisfaction.

In England the use of exhaust-steam injectors on small steam vessels such as lighters, tugs and launches is very common, these working in some cases up to a pressure of 140 lb. gage with marked satisfaction. But, as before stated, there are occasions above 85 lb. gage when a small quantity of live steam must be admitted to accelerate the water. The water is elevated to a point above the injector by means of a pump attached to the engine, and flows by gravity to it. The oil question does not enter to anything like the extent in marine that it does in stationary practice, and there have been very few if any complaints from men with whom I have talked or with installations it has been my pleasure to observe and work with.

I would have no hesitancy in recommending an exhaust-steam injector, provided with a suitable oil separator and a means of supplying the instrument with water at a pressure slightly above the exhaust. The temperature of the water to the injector may range as high as 90 deg. F., without causing trouble due to intermittent operation. To be successful the following three points in brief must be borne in mind: Boiler pressure up to and including 85 lb. gage, a first-class oil separator and a water supply to the instrument under pressure, as they will not lift except when provided with auxiliary lifting jets of live steam, which of course tends to decrease the efficiency of the instrument. With an efficient grease extractor there is no more danger of fouling the boilers with oil than with the use of an open feed-water heater, which likewise is dependent upon the thoroughness with which the oil extractor performs its work.

J. W. CONNOLLY.
Haskell, N. J.

Pipe Stoppages in New Heating Systems

Regarding the use and abuse of dope inside of pipe fittings (page 488, issue of Oct. 1) my experience has been as follows: The first job of steam fitting for heating that I erected was put together with nothing but lubricating oil on the threads—put together "iron to iron." When tested, not a leak appeared on the whole job. For a long time I was an enthusiastic advocate of putting all dope on the outside of the pipe threads, but one experience caused me to modify my ideas.

I had to make several joints on a cold-water pipe line, away from the shop with barely enough fittings to complete the work and only white lead for dope. When the work was tested, one bad leak developed. Three attempts with dope on the outside proved futile. I then put white lead on the inside of the fitting and made up the joint. It proved to be satisfactory, and the joint has remained tight. I now use graphite mixed with cylinder oil and put it on the inside of all fittings.

New Haven, Conn. W. H. WAKEMAN.

Side-Wall Clinker Prevention

In the issue of Oct. 22, beginning on page 598, there is an article, "Side-Wall Clinker Prevention," that contains somewhat misleading statements, which I desire to correct.

In describing the clinker-preventive system in the side walls of the boilers at the River Station of the Buffalo General Electric Co., it is stated that the 1¼-in. steam line which is led into the 4-in. air line leading to the cast-iron boxes serves the purpose of an inspirator to draw air into the 4-in. line. As a matter of fact the 4-in. line which is connected to the cast-iron

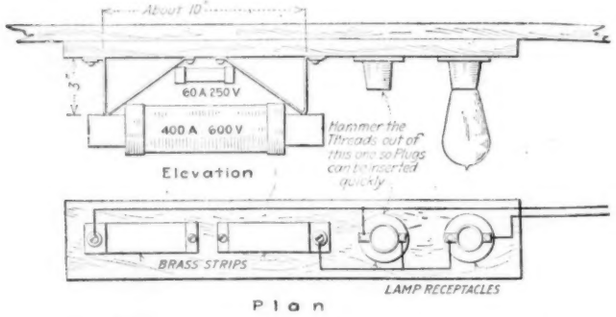
distribution boxes opens into the windbox or plenum chamber under the stokers, and as there is a wind pressure of from four to six inches in this chamber, it can be seen that an inspirator is not necessary. The real purpose of the 1¼-in. line is to furnish a certain amount of moisture with the air entering the furnace through the distribution boxes, tending to soften the clinker on the walls and so make it easier to remove. The steam used is the exhaust from the stoker engines, and the amount of steam admitted to the distribution boxes is controlled by a valve.

It might be of interest to note that this device performed so well that at the end of the first eighteen months of operation the furnace side walls were in practically as good shape as the day they were put in.

Hazleton, Penn. F. C. TORRANCE.

Another Fuse-Testing Board

The illustration shows a fuse-testing board that I made for my own use. Although somewhat more elaborate than the one shown and described by B. Dan De Pass in the issue of Aug. 20, page 282, it is easily



FUSE-TESTING CLIPS MOUNTED UNDER A SHELF

made. It is preferably mounted in the position shown, on the under side of a shelf or some such convenient place. Any type or size of fuse can be tested without making adjustments, and if located out of harm's way the current may be left on continuously.

The illustration is, I believe, sufficiently clear and complete to enable anyone to proceed to make one for himself. J. E. JOHNSTON.

Denver, Colo.

Reducing Valve in Wrong Place

I had an experience somewhat similar to that described by James E. Noble in his letter on page 572 in the issue of Oct. 15. With 100 lb. pressure in the basement of a seven-story building, I wanted 10 lb. pressure on a steam-jacketed vat on the seventh floor. I ran the pipe straight up from the boiler to the vat, but put the reducing valve down at the boiler. Condensation gathered above the reducing valve until the head was enough to hold the valve shut, with the steam-jacket drain valve wide open. Changing the reducing valve from the boiler room to the seventh floor cured the trouble.

Referring to William H. Watson's letter on page 573 of the same issue dealing with "Wiping Commutators," I might add one point: I use an ordinary wax candle, and the wick keeps the hot commutator from melting off too much of the wax. I have run the exciter for the last 5½ years with one set of graphite brushes and one candle, and neither brushes nor candle is worn out yet. R. MANLY ORR.

Vancouver, B. C., Canada.

Disastrous Flywheel Explosion

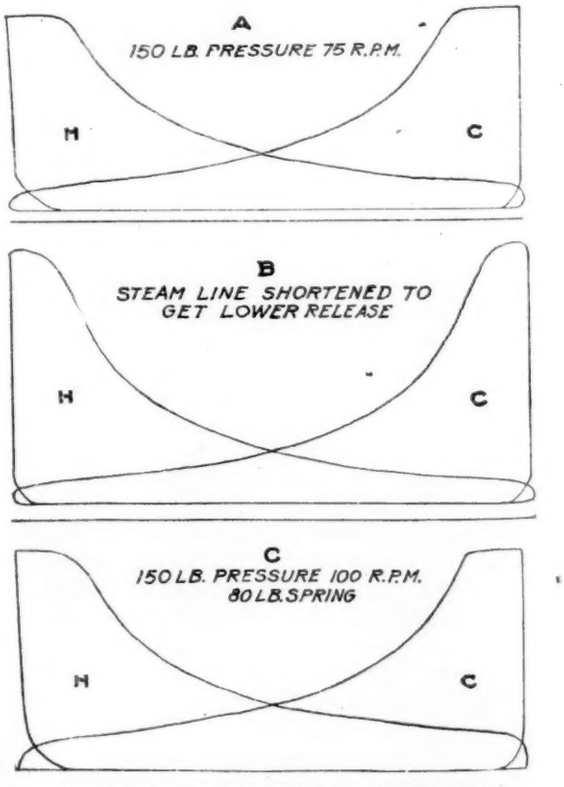
On page 516 in the issue of Oct. 8, in the description of the flywheel accident at the Chicago Coated Board Co., I note the following: "The engine was running along as usual at about 65 per cent. of rating with the throttle two turns open." "The load was constant and the speed normal."—there being no comment as to why the throttle was open only two turns.

The two statements suggest the possibility of a deranged governing mechanism and that the throttle may have been used to control the speed to some extent, which to my mind would be a dangerous practice, especially with a wheel of the type and size mentioned operating at a speed of 103 r.p.m.

Oregon City, Ore. F. L. SANDERS.

Indicator Diagrams for Discussion

The indicator diagram herewith are from a 10 x 12 Laidlaw-Dunn-Gordon air-compressor steam-cylinder located in the Fort Wayne Shops, North Side, Pittsburgh, Penn. This compressor has been in service for



INDICATOR DIAGRAMS FOR CRITICISM

twenty years. I am taking this opportunity to get them before the readers of *Power* for suggestions in regard to possible improvements. They are lettered *A*, *B* and *C* for convenience in referring to them.

Rochester, Penn. G. B. SHEPHARD.

INQUIRIES OF GENERAL INTEREST

Resetting Slipped Eccentric of Link Motion—If one of the eccentrics of a link-valve motion slips on the shaft, how can it be reset? J. G.

Place the engine on a center. If the forward-motion eccentric has slipped, place the reverse lever in the extreme back notch, mark the valve stem close to the gland and then put the reverse lever in the extreme forward-motion notch. Then, remembering that the eccentricity or full part of the eccentrics must be on opposite sides of the crank, turn the loose eccentric around on the shaft until the mark on the valve stem comes to the place where it was made and secure the loose eccentric to the shaft with the setscrews.

Causes of Corrosion in Boilers—What causes corrosion of boilers and what effect has scale in producing corrosion? P. G.

Corrosion is most often caused by the presence of free acid in the feed water, which may result from the supply of water being contaminated from animal or vegetable adulterants in the cylinder oil which find their way into the boiler, or from splitting up of certain salts in the water. Corrosion also may be caused by air liberated from the water when it is heated, and air that is thus liberated is more active than free air in oxidizing metal. The ordinary ingredients of scale have little or no direct corrosive action unless the scale becomes thick enough to cause overheating. A thin coating acts as a protection against corrosion and a thin lime wash on the interior of the boiler is beneficial in retarding corrosion when the feed water contains no scaling ingredients. Pitting and corrosion are usually accompanied by galvanic action and are more active when conditions are favorable to that phenomenon.

Required Thickness for 72-In. Diameter Boiler Shell—What should be the thickness of the shell plates of a 72-in. diameter horizontal return-tubular boiler for a working pressure of 150 lb. per sq.in.? W. M. B.

In addition to diameter and working pressure the thickness of plate required would depend on its tensile strength, the efficiency of the longitudinal joint and factor of safety. The formula for the maximum allowable pressure per square inch is,

$$P = \frac{TS \times t \times E}{R \times F}$$

in which

P = Maximum allowable working pressure per square inch in pounds.
TS = Tensile strength of plate per sq. in. of cross section, lb. per sq. in.;
t = Minimum thickness of shell plates, in inches;
E = Per cent. of efficiency of longitudinal joint;
R = Radius or one half the inside diameter of the outside course of the shell;
F = The factor of safety allowed.

By transposing, the required thickness is given by the formula,

$$t = \frac{P \times R \times F}{TS \times E}$$

In modern boiler construction the longitudinal seam would be a butt and double-strap joint, and if a well-designed quadruple-riveted joint were used, it might have an efficiency of 93 per cent. Hence for $P = 150$ and $R = \frac{1}{2}$ of $72 = 36$; and allowing $F = 5$; $TS = 55{,}000$; and taking $E = 93$ per cent., by substituting in the formula for thickness,

$$t = \frac{150 \times 36 \times 5}{55{,}000 \times 0.93} = \text{or practically } \tfrac{17}{32} \text{ in.}$$

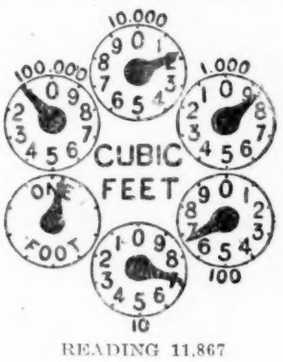
Heat Value of Solid Fuels—What is the relative heat value of solid fuels used for steam boilers? C. R. M.

The heat power of coals per pound of combustible is about constant. The average values of fuels in B.t.u. per pound of dry fuel (and wet fuels as noted) are about as follows:

	B.t.u. per Lb.		B.t.u. per Lb.
Anthracite (small)	12,500	Lignite (dry)	11,300
Anthracite (large)	14,000	Peat	8,100
Semi-anthracite	13,400	Wood (dry)	6,600 to 9,900
Semi-bituminous	15,000	Bagasse (45 to 55 per cent. water)	3,000 to 3,500
Bituminous (as fired)	12,300	Tan bark (with 65 per cent. water)	2,700
Bituminous (dry)	13,200	Tan bark (dry)	9,500
Sub-bituminous	12,000	Straw	5,400 to 6,700
Lignite (as fired)	8,300		

Reading Registration of Water Meter—Kindly explain the correct way of reading a water meter. S. A.

Meters for measuring water are usually graduated in cubic feet, though sometimes in gallons. The unit that is to be taken is plainly marked on the dial plate. One cubic foot is taken commercially as equal to 7½ gal. and to reduce a meter reading in cubic feet to gallons, multiply the number of cubic feet by 7½. The ordinary form of dial is shown by the illustration. The number on the outside of each circle indicates the number of cubic feet for one revolution of the hand. The divisions of the circles are numbered alternately in the counterclockwise and clockwise direction. Thus the first dial (at the bottom) is marked 10 and one division measures 1 cu.ft.; the second 100 and one division measures 10 cu.ft.; the next is marked 1000 and one division measures 100 cu.ft., and similarly for the rest. The small dial at the lower left marked "one foot" measures 1 cu.ft. for a complete revolution and is disregarded in ordinary readings, being used only for test purposes and for detecting leaks when all outlets are presumed to be closed. One division of a circle is equal to a complete revolution of the hand on the circle of next lower value.



READING 11,867

When a hand is between two figures the lesser is to be taken. If a hand is very near a figure, whether that figure or the next lower is to be taken can be determined by observing the hand in the circle of next lower value. Unless the hand on the next lower circle has reached or just passed 0, the lesser figure is to be taken. The best method of recording a reading is from low to high; that is, set down the figures from right to left. For example, the reading of the dial illustrated would be 7 for units place, 6 for tens place, 8 for hundreds place, 1 for thousands place and 1 for ten thousands place, or 11,867 cubic feet.

In larger meters the lowest graduated circle—that is, the one marked 10 corresponding to units place—is sometimes omitted and the lowest circle is marked 100. In that case the figures are to be set down in the same manner, but the lowest figure would be in the tens place and a cipher is to be added for the units place of the complete reading.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. —Editor.]

Condensers and Condenser Engineering Practice—II*

By D. D. PENDLETON

BEFORE definitely fixing the type of condenser to be used, a study of the auxiliaries for the equipment must be gone into very thoroughly. These can be divided into two kinds; motor-driven and steam-turbine or engine-driven.

It is very easy to analyze the power requirements of the motor-driven air pump, circulating pump, hotwell pump, etc., power being taken from the switchboard and representing power not available for sale or other use.

The steam-driven type, however, brings up the question of the return of heat to the feed water, or heat balance, which often so complicates matters that we lose sight of the true power consumed.

Roughly, 90 per cent. of the steam heat of the auxiliaries will be returned as heat to the feed water, provided there is enough water of a suitable temperature to absorb this heat. The amount of feed water available for absorbing this heat varies with the load of the main unit. The result is that at times of light load there is a grave danger of showing an excess of exhaust steam, which has led to the development of combined drives, using turbines and motors.

Another feature to be taken into consideration, is the growing use of economizers in connection with boilers; the colder the water the more work being done by the economizers. This also emphasizes the desirability of avoiding an excessive amount of exhaust steam.

Different Classes of Air Pumps Defined

Air pumps are divided into several classes, as follows:

1. The old type of direct-acting wet pump, being usually a standard steam-driven reciprocating pump, sometimes of the suction valveless type. This cannot go above a 26-in. vacuum.

2. The rotative, or flywheel, direct-acting wet pump, such as the Edwards, Mullen, etc. There are also some well-known types of rotary pumps. All these have their qualifications, but only for a vacuum of less than 28.5 in. under any conditions, and they are quite limited in size and capacity, not being practical for over 40,000 lb. of steam per hour with a 28-in. vacuum. These are rarely used, except for surface work.

3. The reciprocating, rotative crank and flywheel dry-vacuum pump, when used in connection with a proper condensate pump, is really the most efficient in point of power consumption and where space is available, is practical up to, say, 250,000 lb. of steam per hour, at a 28-in. vacuum; but for jet or barometric work at the same vacuum, for only about one-half that amount of steam.

4. The hydraulic or turbo air pumps, such as the A.E.G., Le Blanc, or other suitable types, are very generally used, and, although large consumers of power, they are very well adapted to all types of work where economy of space, convenience of arrangement, layout, etc., make them more practical than other types.

5. The steam jet is fast coming to the front and in some ways proves more desirable than any other type. The equipment usually consists of a two-stage arrangement of two steam jets in series, some using special devices to enable the second jet to handle not only the noncondensable vapors from the condenser, but the steam also from the first jet. The most efficient form now on the market consists of the two-stage arrangement with a condenser (either a small surface or jet) between the first and second stages, so as to condense the steam from the first jet, thereby reducing the work on the second jet and materially increasing the over-all steam economy as well as increasing the air-handling capacity and the vacuum possibilities.

In specifying an air pump, careful consideration should be given the requirements under winter conditions with cold water. If condensing equipment is designed for a 28-in. vacuum with 70-deg. water, the purchaser should reasonably expect a corresponding vacuum with colder water. With water at 35 deg. for surface work, the theoretical vacuum, based on a 15-deg. difference, with a properly designed machine, should be 29.354-in. vacuum, and the same for barometric or jet condensers, based on a 5-deg. difference. No such guarantee can be made by any manufacturer at all, except by designing and furnishing a decidedly abnormal air pump or air-handling equipment. Commercially, the limit is placed at about 29-in. vacuum, unless the purchaser will consider the extra cost to obtain this extra economy.

Centrifugal Circulating-Water Pumps

For the water supply for condensing purposes, there is little call for any type except the centrifugal type. For barometric work, a standard centrifugal pump of high efficiency, say 75 per cent. to 80 per cent., can be used, as also is the case of the circulating pump for the surface condenser and the booster pump for the jet condenser when needed. For the jet condenser, which takes its water by suction, a submerged tail pump is generally used to pump the water away from the vacuum. This is equivalent to operating under a very high suction lift. The efficiency, therefore, of a centrifugal tail pump for a jet condenser, due to the low velocity of water entering the impeller, is seldom over 50 to 60 per cent.

Where surface condensers are used, the condensate is disposed of, usually, in one of three ways:

1. By the use of a wet-vacuum pump which handles both air and condensate. This type cannot pump condensate against any appreciable head outside of condenser and cannot work practically at higher than 28.5 in. vacuum. It can be either steam- or motor-driven.

2. A standard single- or two-stage steam- or motor-driven centrifugal pump is most generally used where an independent air pump, such as the rotative dry pump or the hydraulic or steam jet, is used. This type can be arranged to operate against any desired head outside of the condenser.

3. A duplex steam-driven pump with water-sealed glands is sometimes furnished. A proper float control on the steam valve, regulated by flow of condensate, is always necessary to keep the pump constantly supplied with water and to prevent short-stroking and pounding.

Where water supply is a serious problem, some artificial method of cooling a given supply of circulating water is employed. This is done by cooling towers, spray ponds and natural cooling ponds.

Cooling Towers Classified

Cooling towers may be classified in the following ways: (1) Natural-draft, inclosed type; (2) natural-draft, open or rack type; (3) forced-draft; (4) combined forced and natural draft.

In standard cooling tower practice it has been determined that with the air temperature at 75 deg. F. and at 70 per cent. relative humidity, the most economical vacuum to attempt is 27 in., based on a 30-in. barometer, or a vacuum having a temperature of 115 deg. F. Rating all three types of condensers on a 5-deg. difference, thus requiring a minimum, uniform amount of water, it will be necessary to cool the water from 110 deg. F. Commercially, under the given air conditions, it has been found practicable to cool to only 85 deg. F. or sometimes to 80 deg. F., giving a 25- or 30-deg. cooling range, which with steam at 1000 B.t.u. per pound would require 40 and 33.3 lb. of water per pound of steam, respectively.

The type of equipment to select would depend upon existing local conditions, such as space available and power

*Abstract of a paper presented at the twelfth annual convention of the Association of Iron and Steel Electrical Engineers, Baltimore, Maryland, September, 1918.

consumption. The natural-draft open type requires more ground space and can be placed only where the vapors and driftage will do no harm to surrounding buildings or property, being seriously affected by wind conditions. This type requires a pumping head of approximately 30 ft., and no other power.

The natural-draft, inclosed chimney type takes less ground space. The chimney, or stack, is usually about 75 ft. high, this causing a positive draft at all times. It requires a pumping head of about 25 ft. and no other power, and will be practically independent of wind conditions.

The forced-draft type requires less floor space than any other type, but calls for a pumping head of about 30 to 35 ft., and an additional amount of power for driving the fans, giving a draft independent of atmospheric conditions.

The combination forced-draft and natural-draft tower requires less floor space than the chimney type, natural-draft machine and more than the forced-draft machine, and requires about the same pumping head as the natural-draft chimney-type machine, plus the power to drive the fans when operating under forced-draft conditions. This type has the advantage of conservation of power under favorable atmospheric conditions, or of combining the forced and natural draft under adverse conditions.

It is impossible to state generally the area of a pond for a given quantity of water, but generally speaking, at a working pressure of 6 to 8 lb. on the spray nozzle, a pond of 3 sq.ft. per gallon of water sprayed will be necessary. There are quite a number of details to be considered, all having vital bearing on the subject of spray-nozzle cooling.

First, for spray nozzles, the cooling effect can be increased by increasing the pressure at the nozzle. An increase of from 5 to 20 lb. would show an increase of from 1 to 12 per cent. in cooling. The size of the nozzle should also be considered. Assuming a given size nozzle as rated at 100 per cent., an increase of up to 135 per cent. can be obtained by decreasing the size, while by increasing the size, a decrease to 60 per cent. will be shown in the rated efficiency or cooling effect.

The size of the pond or its storage capacity is a very valuable asset, in that the greater the storage volume the more time it requires in continuous service to pass it through the condenser. This time causes and equals what is called the lag in the pond temperature. The greater the lag, the lower will be the average temperature in the pond. Therefore the mean atmospheric conditions over the lag period can be assumed. Sprays are usually arranged in groups, so that free access by the air can be obtained at all times. The groups are arranged in single or double deck, depending upon the space conditions.

The area of a natural cooling pond is obviously very large, as the heat dissipated per square foot depends upon the relative humidity, the temperature of the water and the velocity of the air currents. These are naturally, on account of varied conditions, very discordant. Quoting from Gebhardt's "Steam Power Plant Engineering": "It appears from tests that under ordinary conditions, in the northern part of the United States, with engines using 15 lb. of water per horsepower-hour and a vacuum of 26 in., a reservoir having a surface of 120 sq.ft. per horsepower would be ample for cooling the condensing water."

This would mean about 60 sq.ft. for each gallon of condensing water for a 26-in. vacuum, which, of course, would be greatly increased for a higher vacuum. The advantages, therefore, are of course with spraying under pressure.

In any water-cooling device 90 per cent. of the cooling effect is through evaporation, and it is therefore of vital importance that sufficient unsaturated air be given free access to the proper quantity of water. The air in all cases should go off the tower or pond in a saturated condition.

Boiler Explosion in Detroit Injures Four

At 7:30 in the morning of Nov. 1 a 150-hp. return-tubular boiler in the plant of the Wadsworth Manufacturing Co., Detroit, Mich., exploded, injuring four men and causing partial destruction of the setting. The company is a manufacturer of automobile bodies and recently has been shut down. Heat from one boiler, however, had been supplied to the offices and to the McCord Manufacturing Co., next door. Over night the boiler was banked and the fireman came on duty about 6 a.m. On the morning of the accident there apparently had been a heavy bank as the recording gage on the header showed that the steam pressure holding over exceeded 100 lb. The setting was steel incased and probably air-tight.

According to reports the fireman, soon after entering the plant, stirred up the fire and opened the valve admitting steam to the heating system. The pressure immediately dropped to 10 lb. and from the record of the gage remained there until the explosion occurred, when a sharp rise to 110 lb. is indicated. After opening the valve the fireman threw on a heavy fire and then proceeded to start the pump. Some delay must have occurred or the fireman was later than usual in starting up, for as soon as the cold water entered the boiler, about 7:30 a.m., the explosion occurred.

The front sheet over the fire had apparently overheated and, with the sudden rise in pressure with the introduction of the water, let go, the rupture being about 4 ft. long and 7 in. wide. The steam escaping into the furnace bulged out the boiler front about 18 in., blew open the doors and scalded four men standing in the immediate vicinity. One is badly hurt and the other three less seriously, although at the time of writing all are still in the hospital. The boiler shell still hangs from its I-beam supports and the other boiler of the battery of two is undamaged. Bricks from the outside wall of the ruptured boiler fell into the furnace, and a few firebrick on the division wall were loosened. The damage was comparatively slight.

Weekly Letter Plan To Aid Coal Conservation in Illinois

To keep before power-plant owners and operators the various economies that will effect the saving in coal requested by the Fuel Administration and to maintain interest at the proper pitch in conservation, Joseph Harrington, administrative engineer for Illinois, has adopted the plan of weekly letters to all plants in the state. In each letter one specific subject will be treated, and it is the intention that the entire week be given by each owner to a careful examination of his plant with reference to the subject of the letter. If improvements are possible, immediate steps are to be taken to better conditions. During the following week there will be another letter on a different subject and so on until all factors influencing economy in the boiler room have been covered.

The series has already started with a general letter and a questionnaire on coal storage. The third letter is now being sent out. "Directions for Operating Hand-Fired Boilers," adapted from a contribution by A. Bement, is the subject for the week. A copy of the letter should be posted in the boiler room and all concerned should give it their undivided attention. In weeks to follow there will be letters on boiler covering, flue-gas analysis, coal weighing, soot, water purification, boiler-room records, etc. The letters are to be preserved, and at the conclusion of the series will form a valuable collection. The plan is to be highly commended. It is to the interest of every plant in the state to coöperate, and from a patriotic standpoint it is a duty to the state. During the present week firing methods should be studied with a view to improvement in each particular plant. A copy of the letter follows:

Blowing Flues and Similar Work—Blowing and scraping of the fire surfaces of boilers should be done at a time when it will least interfere with the work of attending to the fires. If the fireman is compelled to blow flues in the morning when he should be giving his best attention to the fires, economy will suffer.

Number of Boilers To Be Kept in Service—The smallest number of boilers that can carry the load should be employed. With those plants having a variable load with a peak occurring at some period, the day should be started with the smallest number of boilers in use that will carry the load and additional boilers should not be fired until needed for additional load. This is a matter that should have the closest attention and be carefully studied to see how late boilers may be started without being short of

steam. Just as fast as the load goes off, boilers should be dropped out of service and banked.

Method of Firing—In using mine-run or lump coal, the lumps should be well broken up. With screenings or the fine portion of mine-run the coal will cake, and these caked masses should be carefully broken on the top after the cake has formed. This should be done with a light rake, but the fire should not be stirred or poked. Under no circumstances should the slice bar be run under the fire to free it. If the fire is dirty, it should be cleaned. If shaking grates are used, they should be shaken frequently, as this will remove the ashes, making a better fire and less fire cleaning. The coal should be evenly spread over all the surface of the fire, giving special attention to the side and corners so as always maintaining a good, strong, hot fire. While a good fire bed should be maintained, care should be taken that it does not get too thick.

Draft Control—A good, strong fire may make too much steam if the draft is strong. Thereafter, the fireman should adjust the individual draft damper on each boiler as often as necessary to burn the fire at the proper rate.

When Furnace Should Be Fired—The time to replenish the fire by adding more coal is when the fuel bed has burned down below the normal, standard condition, the idea being to maintain at all times a uniform, economical fire. This proceeding is contrary to the usual practice in which the fireman waits until the steam falls, and then adds more coal.

To Control Steam Pressure—The steam pressure should be controlled by the draft, as the speed at which the fire is burned, or heat is produced, is dependent upon the amount of opening given the damper. Therefore, if steam is rising, the damper should be checked; if it falls, it should be opened. In this way the steam gage will show when to open and close the damper, and the appearance of the fire will indicate when the furnace should be fired.

Night Service—When fires are banked at night, the draft should be cut off so that the bank will lie without burning. In the winter time, when steam is needed for heating, the same kind of fire should be maintained as in the daytime, and the draft should be controlled in the same manner as during the day.

In carrying out this program, the use of unnecessary boilers in service, which result only in burning up coal without its being of benefit, will be eliminated, an economical fire will be maintained all the time the boiler is in service, and by controlling the draft the fire will be burned only as required. When much steam is needed, dampers will be opened and the fire will burn faster, requiring more frequent replenishing to maintain the standard, uniform conditions. When less steam is demanded, dampers will be correspondingly closed, the fire will burn more slowly and require less frequent coaling to maintain a good uniform condition. In this way an economical fire will be maintained at all times, and it will be burned at the rate required to supply the steam needed. The steam gage will show when to adjust the dampers, and the appearance of the fire when to supply more coal.

Remember—Always keep an even fire. The rear of the fire burns fastest. Look out for holes. Do not pile the coal up in the doorway so you cannot see the fire. Use the boiler damper freely—that's what it's made for.

Illinois expects every man to do his duty.

Failure of an 18-In. Steam Header

A news item published on page 687 of the Nov. 5 issue stated that an 18-in. steam header at the plant of the Memphis-Tennessee Gas and Electric Co. failed on the morning of Oct. 28.

Information has since been received that the header was of extra-heavy pipe and was connected to nine boilers, and at the time of the accident was working under 180 lb. pressure, the steam being superheated 125 deg. The failure of the header was due to a flange pulling off the pipe at about midway of its length. The threads on the flange and pipe showed no signs of stripping and were apparently as good as new. When the flange was again screwed onto the pipe, it was very loose, so much so that it went on about ¾ in. farther than originally and only stopped when the threads ceased. This header, it is stated, had been in use about 17 years.

As the pipe spread apart about 8 in. in a longitudinal direction, the steam escaping from both sections was opposed and somewhat retarded the flow of steam from the boilers. Nearly 30 minutes was consumed in emptying the boilers of steam.

As soon as the accident happened, a negro water tender groped through the steam and shut down the forced-draft fans. One man, who was on top of the boilers when the header failed, inhaled steam and later died.

A new section of pipe was ordered as soon as the extent of the damage was ascertained, and the plant is doubtless again in operation at this writing.

A 35,000-Kv.-A. Generator at Philadelphia Burns Out

On Friday, Nov. 8, two coils burned out of the generator of the 35,000-kv.-a. tandem-compound, impulse turbine in the plant of the Philadelphia Electric Co., Philadelphia, Penn. For many months this machine has been heavily loaded, carrying 30,000 kw. during the day and 20,000 kw. during night runs. Two coils only were burned out Corona shields were used.

On Feb. 25, 1917, several coils burned out of the armature of this machine following trouble on the transmission line. The coils affected were near a previously repaired coil. The machine has since been provided with a grounded neutral.

The loss in power is, of course, serious on account of the power shortage in the Philadelphia district; but the turbine will be shut down for a short time only as all facilities have been directed toward a quick repair.

Depth bombs used in hunting submarines may be dropped from air or seaplane, or from any destroyer or other craft on the submarine that has been located. They contain trinitrotoluol which, on being detonated under water, causes a violent compression wave, sufficient to smash the hull of any submarine. Depth bombs are of two kinds. One kind is exploded solely by means of water pressure, and the other by a fuse and detonator regulated to any required depth. Other depth bombs vary only in detail from the general principle, the differences being in their devices for time discharging. A special type of bomb used by airplanes is a pointed cylinder containing the explosive, at the upper end of which is a detonator and a small electric battery. An insulated electric cable containing two wires is attached to the upper part of the cylinder and leads to a relatively small parachute which serves to straighten out the cable when the bomb and its attachments descend. Just beneath the parachute is an aluminum disk on the lower side of which is mounted a flexible diaphragm. When the diaphragm strikes the water in trailing along after the bomb at the end of the cable, it is driven inward and causes an electric contact to be made between the end of the wires coming up through the cable, which in turn causes the bomb's explosion at a depth below the surface determined by the cable's length.—*The Indian Engineer, Bombay.*

Accidents at metallurgical works in the United States during the calendar year 1916, according to the third report of the Bureau of Mines, compiled by Albert H. Fay, show a gratifying reduction in fatalities at both smelters and ore-dressing plants. The nonfatal injuries show an increase, caused not so much by an increasing hazard as by the more complete returns received. The figures cover the returns from 150 smelting plants and include copper, lead, zinc and quicksilver smelters, as well as refineries. Iron blast furnaces are not included in the figures given. The ore-dressing plants represent concentrating plants for copper, lead, and zinc ores, stamp mills, cyanide plants and iron-ore washers. The total number of men reported employed in the metallurgical plants, both smelters and ore-dressing plants, was 66,194, as compared with 49,891 in 1915, and 43,007 in 1914. The number of fatalities reported was 83 at metallurgical plants, 33 at ore-dressing plants, 36 at smelters and 14 at auxiliary works, including shops, yards, etc. The number of nonfatal injuries reported was 15,080.

New Publications

WATER-GAS MANUFACTURE WITH CENTRAL-DISTRICT BITUMINOUS COALS AS GENERATOR FUEL. By W. W. Odell and W. A. Dunkley. Paper; 6 x 9 in.; 24 pages; 3 illustrations.

This publication is Bulletin 22 of the Coöperative Mining Series and is devoted to the manufacture of water-gas from Indiana, Illinois and Kentucky coal. It points out the objections to the use of such fuel and methods of overcoming these objections and gives information as to the cost of materials, labor and repairs. Copies of the bulletin may be obtained from the Engineering Experiment Station, University of Illinois, Urbana, Ill.

HOW TO IMPROVE THE HOT-AIR FURNACE. By Charles Whiting Baker. Published by the Bureau of Mines, Washington, D. C. 20 pages; 6 x 9 in. Price, 5 cents.

This pamphlet is Technical Paper 208 and is a reprint of Mr. Baker's paper on this subject delivered before the American Society of Heating and Ventilating Engineers at Buffalo last June. It points out certain defects in existing types of hot-air heating plants and suggests a number of improvements in construction and operation that will add to the comfort of the householder and at the same time lessen his coal bills.

THE MANUFACTURE OF RETORT COAL GAS IN THE CENTRAL STATES USING LOW-SULPHUR COAL FROM ILLINOIS, INDIANA AND WESTERN KENTUCKY.

The difficulty of obtaining Eastern gas coal and coke in the Central States, because of the zone distribution of coal now in effect, has led to the investigation of the use of low-sulphur coal from Illinois, Indiana and western Kentucky for gas manufacture. This bulletin, which is No. 21 of the Coöperative Mining Series, describes the problems in the use of central-district coal for gas manufacture, the results obtained, and a comparison of the approximate costs of making gas from central-district and Eastern coals. Copies of the bulletin may be had from the State Geological Survey, Urbana, Ill.

NOTES ON LIGNITE—ITS CHARACTERISTICS AND UTILIZATION. By S. M. Darling. Technical Paper 178 of the Bureau of Mines.

There are considerable lignite deposits in the Dakotas and Minnesota, yet the greater part of the fuel used in these states is imported from distant coal fields, involving long hauls. Such a condition is not economical, but it cannot be remedied until lignite as a fuel is made more generally available. These notes on lignite are intended to point out some of the ways in which that fuel may be used economically. It cannot be used in its raw form, except in the immediate neighborhood of the mine, because it contains 30 per cent. of moisture. Instead, it must be modified so as to produce several products, each adapted to a particular commercial need, such as: Dried lignite for use with stokers or in gas producers; powdered fuel for use in furnaces, kilns and locomotives; dried briquets for large hand-fired industrial furnaces; carbonized lignite for use in suction producers; carbonized lignite briquets for use in domestic stoves and furnaces; and sulphate of ammonia and producer gas as obtained by the Mond process.

This publication gives much information as to the byproducts obtainable from lignite and will be of interest and value to anyone who is studying the problem of utilizing lignite as fuel.

THE ECONOMICAL USE OF COAL IN RAILWAY LOCOMOTIVES

The Engineering Experiment Station of the University of Illinois, Urbana, has issued a circular bearing this title, which presents some suggestions concerning ways in which large coal savings may be made. The facts presented were compiled by a special committee of the research staff of the Engineering Experiment Station, assisted by an advisory committee. The circular is printed in four colors and the price is 20 cents. It may be had by addressing Engineering Experiment Station, Urbana, Ill.

Personals

LeRoy Gordon has been appointed eastern representative of the N. C. Davison Gas Burner & Welding Co., of Pittsburgh, Penn., with office at 51 E. 42nd St., New York City.

R. H. Angell, of Roanoke, has been appointed by U. S. Fuel Administrator H. A. Garfield to be Federal Fuel Administrator for Virginia in the place of H. F. Byrd, who has entered the military service. Mr. Angell, who is a well known banker and business man of Roanoke, was at the time of his appointment Local Fuel Administrator at that place.

H. L. Treeman has been promoted by The J. G. White Management Corp., New York, from industrial engineer of that organization to the position of manager of the electric department of the Eastern Pennsylvania Railways Co. and the Eastern Pennsylvania Light, Heat and Power Co., of Pottsville, Penn. Both of these utilities are operated by the management corporation. Mr. Treeman was associated with the Edison Electric Illuminating Co. of Brooklyn as power engineer for a number of years.

Engineering Affairs

The American Institute of Electrical Engineers will hold its 344th meeting, under the auspices of the Toronto (Canada) Section at Toronto, Nov. 22-23, with headquarters at the Engineers' Club.

The Association of Iron and Steel Electrical Engineers will hold a meeting at the Chatham Hotel, Pittsburgh, Penn., on Nov. 23. J. E. Fries will read a paper entitled "Sixty-Cycle versus Twenty-five-Cycle Power for Steel Mills."

Officers of the National Association of Stationary Engineers visited Huntington (W. Va.) on Nov. 8, to confirm the claims for the city which induced the association at its convention in Cincinnati in September to hold its next annual meeting there. The visitors were F. W. Raven, national secretary of the association, Sam Forse, national treasurer, and T. Green, secretary of the exhibitors' association. Secretary H. Matthews, of the Chamber of Commerce, conducted them about in the early part of the day, and later they were shown around the city by D. A. Mossman, chairman of the new industries committee of the chamber. In the evening they were guests of honor at a dinner at the Frederick Hotel. The other diners were Secretary Matthews, W. W. Smith, chairman of the convention committee of the chamber; R. D. Wyllie, the members of the local branch of stationary engineers, and James Fields, state deputy for that organization.

Miscellaneous News

War Industries Board Takes Charge of Turbine Plants.—The control of about twenty plants manufacturing steam turbines has been taken over by the War Industries Board. The sale of all turbines of 700 hp. or over except those for the Navy and the Emergency Fleet Corporation will be under the supervision of the board. This action has become necessary in order to equitably allot the output from and the material for these plants.

Manufacturers and Coal Operators who have been discussing the matter of building an electric light and power plant in the heart of the Monongalia coal field, near Morgantown, W. Va., are furthering plans in that direction, and it is not improbable that something definite will be done in the near future. Plans and specifications for boilers, turbines, generators and other electrical equipment are already on hand, and estimates of the cost of building an adequate plant and installing machinery are being prepared. It is believed that such a plant in the coal fields would not only prove a paying investment, but would add materially to the coal output, an end greatly to be desired. Coal operators claim that the plant of the West Virginia Traction and Electric Co. in Charleston is hardly equal to supplying the demand for current. The coal output is being curtailed through lack of a sufficient supply of electric current, and for this reason it is believed that there would be no difficulty in getting the necessary permission for the construction of a new plant. Manufacturers and coal operators who have considered the matter say there would be no difficulty in securing the necessary capital. Almost without exception they have agreed to take stock in substantial quantities.

Business Items

G. A. Binz, sales manager of the Yarnall-Waring Co., Philadelphia, has transferred his headquarters to the company's New York office at 90 West St., and will in future devote his whole time to the interests of "Yarway" specialties in that area.

Trade Catalogs

Coppus Turbo Blower, Coppus Engineering and Equipment Co., Worcester, Mass. Pages 52; 5¾ x 8¾ in. An up-to-date catalog containing figures and tables of forced draft apparatus.

Tate-Jones & Co., Inc., Pittsburgh, Penn., have just issued a very useful booklet entitled "Fuel Oil and Its Use," which contains much information applicable to present day fuel problems.

New Construction

PROPOSED WORK

Mass., Chelsea—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the installation of a steam heating system here, Specification No. 3597. Estimated cost, $25,000. Noted Nov. 5.

N. Y., Buffalo—The Buffalo Dry Docks Co., Ganson St., plans to build a 1-story, 22 x 50 ft. boiler house addition.

N. Y., Montauk—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build extensions to heating system here, Specification No. 3639. Estimated cost, $15,000.

N. Y., New York—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build extension "A" to power plant, Specification No. 3632. Estimated cost, $175,000.

N. Y., Port Jefferson—The Watercraft Construction Co., Flushing Bay, will install a steam heating system in the 2-story, 50 x 100 ft. boiler plant which it will will build. The company is in the market for air machines, compressors and boilers. Total estimated cost, $20,000.

Penn., Ardmore—Robley E. Warner, Supt. Commissioners of Lower Merion Twp., will receive bids until Nov. 26 for furnishing material and machinery in connection with the complete installation of a 125-hp. electric motor and centrifugal pump for pumping sewage at Mill Creek pumping station.

Penn., Philadelphia—The Knot Manufacturing Co., Clifton Heights, plans to build a 1-story, 60 x 88 ft. engine plant.

Md., Baltimore—The Consolidated Gas, Electric Light & Power Co., Lexington and Liberty St., plans to build extensive additions and improvements to the Westport power station. Project includes two large additions to the boiler house, each containing 6 boilers of about 1000 hp. each, etc. Cost will run into millions. E. Edmonston, Gen. Supt.

Md., Fairfield—The Union Shipbuilding Co. plans to construct a 1-story boiler house

Va., Quantico—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to construct an electric power plant here. Estimated cost, $45,000.

Va., Richmond—The Air Reduction Co., 120 Broadway, New York City, N. Y., will install a steam heating system in the 1-story, 60 x 100 ft. plant which it plans to build. The company is in the market for motors. Total estimated cost, $100,000.

W. Va., Affinity—The E. E. White Coal Co. plans to enlarge its power house by installing a 300-kw. A.C. machine and a 150-kw. D.C. machine with new battery of boilers.

S. C., Tatum—Stewart & Co. is in the market for two second hand 40-hp. steam boilers and 16 to 24 hp. and 8 to 12 hp. engines.

Ga., Rome—The City Commissioners plan to install equipment in the water-works pumping station to generate electricity for power and lighting.

Ohio, Cleveland—The Aluminum Castings Co., Harvard Ave., plans to build a power house on Harvard Ave. near 32nd St. J. H. Williams, Engr., c/o Owner, drawing preliminary plans.

Ohio, Cleveland—The Capital Issues Committee has approved a bond issue of $300,000 to complete the new municipal light plant on East 53rd St. It is estimated that the present capacity of 15,000 kilowatts will be increased by 10,000 kilowatts when the new plant is in operation.

Mich., Portland—The Board of Education will install a steam boiler, pump, etc., in the proposed 2-story, 74 x 140 ft. high school building. Thomas E. White, 312 City National Bank Bldg., Lansing, Arch.

Wis., Hartford—Robert A. Messmer & Bro., Arch., 1004 Majestic Bldg., Milwaukee, is preparing plans for the construction of a 40 x 40 ft. boiler and engine house for the Hartford Canning Co., to be used in connection with its new factory. A. Law, Gen. Mgr.

Wis., Milwaukee—The Milwaukee Electric Railway & Light Co., Public Service Bldg., plans to construct and equip a large steam generating plant.

Wis., Sheboygan Falls—Captain Ernest Gonzenbach has purchased the plant of the Falls Roller Mills here, and plans to enlarge the hydro-electric installation to engage in commercial light and power business.

Minn., Worthington—W. H. Buchan, City Clerk, will soon award the contract for the construction of a power plant. C. L. Pillsbury, 813 Metropolitan Life Bldg., Minneapolis, Engr.

Tex., Ranger—The Chamber of Commerce plans to construct an electric lighting system.

Tex., Waco—A Symes plans to install a pumping plant on the Brazos River to irrigate 225 acres.

Cal., Butte City—The Great Western Canal Co. plans to construct a new electric power plant with a capacity of over 100,000 hp.

Cal., Palmdale—The Palmdale Irrigation District plans the installation of new electrically operated pumping plants in the Antelope Valley Section. Estimated cost, $500,000.

Sask., Estevan—The city plans to construct a gas producer power plant to generate 9000 kilowatts of power from the lignite coal beds. Estimated cost, $1,620,000.

CONTRACTS AWARDED

Conn., New London—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for constructing extensions to boiler plant and barracks, to the Oscawanna Building Co., 101 Park Ave., New York City, N. Y. Estimated cost, $172,700.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing heating and ventilating system in ward building "E" at Naval Hospital, from S. W. Rittenhouse, 1316 Harvard St., Washington, D. C. Estimated cost, $77,824.

N. J., South Amboy—The Raritan River Road Co., 15 Exchange Place, Jersey City, has awarded the contract for the construction of boiler house, store house, etc., here, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Total estimated cost, $200,000.

Penn., Etnaria—The Imbrie Coal Co., Butler, will build a 40 x 65 ft. power house here. C. D. Hall Co., 6136 Jenkins Arcade, Pittsburgh, Engr.

Penn., Hauto—The Lehigh Navigation Electric Co., 802 Hamilton St., Allentown, has awarded the contract for the construction of an addition to its power plant, to the Phoenix Construction Co., 81 Broadway, New York City, N. Y. Estimated cost, $1,250,000.

Penn., Herminie—The Ocean Coal Co. has awarded the contract for the construction of an addition to the power plant at the Berwind-White No. 2 plant, to C. E. Miller.

Penn., Sharon—The Savage Arms Corp., 50 Church St., New York City, N. Y., has awarded the contract for the construction of a power plant to Stone & Webster, 147 Milk St., Boston, Mass. Estimated cost, $300,000. Noted Nov. 12.

Md., Curtis Bay—The American Car & Foundry Co. has awarded the contract for the construction of a 1-story transformer house to the McAleer Construction Co., 15 East Fayette St., Baltimore. Estimated cost, $8000.

Ohio, Massillon—The Massillon Gas and Electric Co. has awarded the contract for the construction of an addition to its power plant to the Republic Construction Co. F. L. O'Connor, Supt.

Ind., Indianapolis—The Van Camp Packing Co., 600 Kentucky Ave., has awarded the contract for the construction of a 1-story, 84 x 113 ft. power house, to the Bedford Stone & Construction Co., 810 Fletcher Savings & Trust Bldg.

Ill., Chicago—The Skinner Packing Co., 27th and Y St., has awarded the contract for the construction of a 1-story, 84 x 84 ft. power plant, to Collins Bros., 536 Rialto Bldg., Kansas City, Mo. Estimated cost, $50,000.

Ill., Great Lakes—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a power house and 2 storehouses, to H. F. Friestedt Co., 327 South LaSalle St., Chicago. Estimated cost, $163,661. Noted Aug. 13.

Minn., Rochester—The State Board of Control has awarded the contract for repairing power house, to Frank A. Taylor. D. F. Mullen, Secy.

Neb., Omaha—The Skinner Packing Co., 1400 First National Bank Bldg., has awarded the contract for the construction of a power plant, to Collins Bros., 6023 South 27th St. Estimated cost, $50,000.

Neb., Sterling—The city awarded the contract for constructing an electric transmission line from Tecumseh to Sterling, to the Western Electrical Co., Omaha. Estimated cost, $10,364.

Tex., Delhart—The Chicago, Rock Island & Pacific R. R. will build a 1-story, 40 x 60 ft. power house here. Estimated cost, $3500. C. A. Morse, Ch. Engr.

Cal., San Diego—L. M. Cox, Commandant, 12th Naval District, has awarded the contract for the construction of seven air school buildings on North Island, to the Los Angeles Planing Mill Co., 1812 Industrial St., Los Angeles. Projects include the construction of a hydrogen generating plant, blower houses, pump houses, etc. Total estimated cost, $58,391. Noted Oct. 15.

Cal., San Jose—The city has awarded the contract for furnishing a 75 hp. motor to the Century Electric Co., 18 East San Antonio St. Estimated cost, $1120.

N. B., St. John—The Department of Public Works, Ottawa, Ont., has awarded the contract for alterations and additions to its power plant to F. S. Walker, 14 Church St. The contractor is in the market for a 75 hp. tubular boiler, 2 pumps and 1 500-gallon Kelly tank.

Que., Grosse Isle—The Department of Public Works, Ottawa, Ont., has awarded the contract for the construction of a boiler house, to T. Beaumont and R. Boulanger, Montmagny.

Ont., Copper Cliff—The International Nickel Co. has awarded the contract for power development to the Fraser-Brace Co., 83 Craig St., W., Montreal, Que. Estimated cost, $2,000,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston. $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$5.50	$6.25	Broken	$6.75	$7.50
Buck.	5.10	5.90	Egg	6.65	7.40
Rice	4.65	5.10	Stove	6.90	7.65
Barley	4.15	4.30	Chestnut	7.00	7.75

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.75	$5.00	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.20		2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.40	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene,			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.